AERONAUTICAL ENGINEERING REVIEW

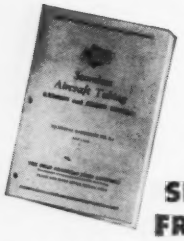
INSTITUTE OF THE AERONAUTICAL SCIENCES

NEW YORK UNIVERSITY LIBRARY APR 21 1949

APRIL 1949

The "Indian Rope Trick" WAS NEVER THIS SLICK!

THE FAMOUS INDIAN ROPE TRICK *takes a back seat when The HRP-1 Rescuer (largest helicopter ever put into production) simultaneously lifts five men into the air and into the ship, via a ladder, without landing. The Rescuer can also lift, deliver and quick-release a jeep or anti-tank gun. Built for the Navy, Marines and Coast Guard by the Piasecki Helicopter Corporation, Morton, Delaware County, Pa.*



SEND FOR FREE BOOK

Write today, without obligation, for your copy of Booklet A-2, containing helpful, factual information on OSTUCO Aircraft Tubing. Address the nearest OSTUCO Sales Office, or write direct to General Office, Shelby, Ohio.

U. S. plane builders are continually coming up with something new and better in aircraft design—pacing the world in air progress. Such advancement calls for structural materials of *minimum weight* and *maximum strength*—and the overwhelming majority of U. S. plane manufacturers are meeting these needs with OSTUCO Aircraft Tubing.

OSTUCO Aircraft Tubing is preferred for engine mounts, strut assemblies, rudder controls, fuselage frames, hydraulic systems and other applications because of its inherent *strength-without-weight* advantages, and because it can be machined, formed and fabricated to the most exacting requirements.

Whatever your aircraft tubing needs, it will pay you to rely on OSTUCO—the supplier with the most extensive engineering and manufacturing experience—the company that made the first "Chrome-Moly" ever produced for aircraft.

Our stock of engine, mechanical and airframe tubing is complete in a wide range of sizes—all precision produced to Army, Navy and AMS specifications. Rejects are extremely low. Immediate deliveries are assured. Get in touch with your nearest OSTUCO Sales Office now.

OSTUCO

THE OHIO SEAMLESS TUBE COMPANY

Plant and General Offices: **SHELBY 2, OHIO**

Sales Offices: CHICAGO, Civic Opera Bldg., 20 North Wacker Dr. CLEVELAND, 1328 Citizens Bldg. • DAYTON, 1517 E. Third Street DETROIT, 2857 E. Grand Blvd. • HOUSTON, 927 A M&M Bldg. LOS ANGELES, Suite 300-170 So. Beverly Drive, Beverly Hills • MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • ST. LOUIS, 1230 North Main St. • SEATTLE, 3205 Smith Tower • SYRACUSE, 501 Roberts Ave. CANADIAN REPRESENTATIVE: Railway & Power Corp., Ltd., NEW GLASGOW, MONTREAL, NORANDA, NORTH BAY, TORONTO, HAMILTON, WINDSOR, WINNIPEG, EDMONTON, VANCOUVER

OSTUCO AIRCRAFT TUBING

It gives the Cutlass an edge

A heavy, super-fast ship like the Navy's new XF7-U tailless twin-jet fighter needs a plus in rugged landing-gear equipment. That's why it is fitted with Goodyear tires, tubes, wheels and brakes. The extra stamina of Goodyear tires and tubes—the extra strength of Goodyear lightweight magnesium alloy wheels—the extra braking power of Goodyear self-adjusting Single Disc Brakes—give the Cutlass a decided edge in safety in making quick, sure stops. For complete information about these and all other Goodyear Aviation Products, write:

Goodyear, Aviation Products
Division, Akron 16, Ohio
or Los Angeles 54, Calif.

GOODYEAR
AVIATION
PRODUCTS

MORE AIRCRAFT LAND ON GOODYEAR TIRES, TUBES, WHEELS AND BRAKES THAN ON ANY OTHER KIND

Typical of many Wyman-Gordon developments is this complicated light alloy forging used in the wing structure of one of Uncle Sam's latest fighting planes.

Modern transportation on the ground and in the air requires the maximum use of forgings. For greatest strength with minimum weight and uniformity of quality no other method of forming metal competes with the forging process.

Are you taking full advantage of the constantly growing range of forgings? Wyman-Gordon forgings all the way from five up to one thousand pounds.

Standard of the Industry for More Than Sixty Years.

WYMAN-GORDON

Forgings of Aluminum, Magnesium, Steel

WORCESTER, MASSACHUSETTS, U. S. A.

HARVEY, ILLINOIS - - - DETROIT, MICHIGAN

Cover—North American Aviation's T-28 Air Force Trainer.

Editor
Welman A. Shrader

Technical Advisers
Hugh L. Dryden — Robert R. Dexter
S. Paul Johnston

Associate Editor — B. H. Jarck
Reviews Editor — John J. Glennon
News Editor — Randolph Hawthorne
Asst. Reviews Editor — Lyons T. Carr

Manager
Joseph P. Ryan

Manager, Western Region
James L. Straight
6715 Hollywood Blvd., Los Angeles 28, Calif.

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y.

Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinions expressed in the *Aeronautical Engineering Review* are to be understood as individual expressions and not those of the Institute.

Copyright, 1949, by the Institute of the Aeronautical Sciences, Inc.

AERONAUTICAL ENGINEERING REVIEW

Vol. 8 — APRIL, 1949 — No. 4

Contents

I.A.S. News 5

Editorial 19

Articles

Convertible Aircraft . . . . . R. S. Barnaby, S. M. Berkowitz, and W. H. Colcord 20

Synthetic Aircraft . . . . . Luis de Florez 26

Human Problems in the Design and Operation of Air Transports . . . . . Ross A. McFarland 30

I.A.S. Seventeenth Annual Meeting. Technical Sessions—Part II . . . . . Dr. Alexander Klemin 34

Reviews

Aeronautical Reviews 49

Books 89

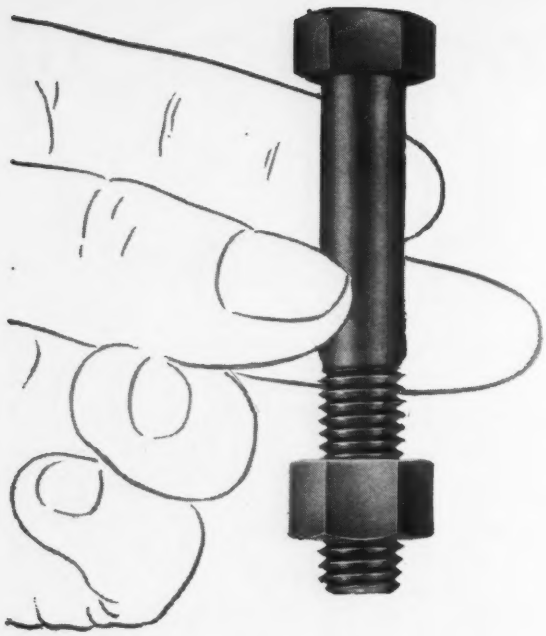
I.A.S. Preprints 46

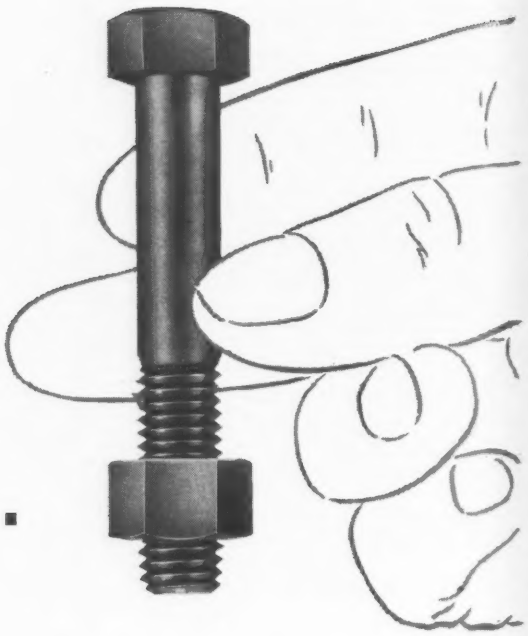
Special I.A.S. Publications 47

Personnel Opportunities 103

Index to Advertisers 107

Published Monthly by the Institute of the Aeronautical Sciences, Inc.





They look alike...

but one is 7 ways better!

One bolt is made of Monel.*
The other is an ordinary fastening.
To men who know their metals, that's the same as saying the first bolt is 7 ways better.
For a Monel fastening—

1. Is 20% stronger
2. Is 30% more ductile
3. Is 40% tougher

...than the free-cutting steel from which fastenings are usually made

4. Stands heat or sub-zero cold
5. Never rusts
6. Resists corrosion by salt water, caustics and most acids
7. Provides greater safety

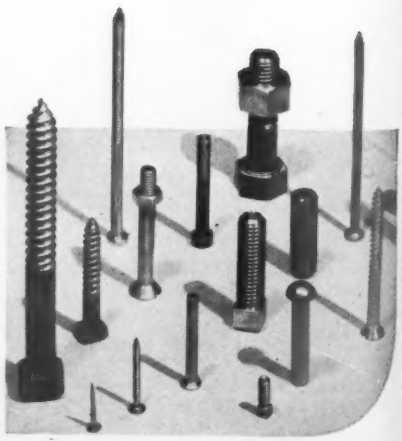
How many places could you use the seven extras that Monel fastenings provide?

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE
INCO
TRADE MARK

TEST MONEL FASTENINGS YOURSELF. *What type and size do you need, in order to try free test sample of Monel fastenings in your worst problem? Bob Johnson of Inco will send you sample and list of distributors.*



I.A.S. News

A Record of People and Events of Interest to Institute Members

Personal Aircraft Meeting Date Changed to April 29–30

Dr. C. C. Furnas, of Cornell Aeronautical Lab., to Be Guest Dinner Speaker at Hotel Allis; Personal Aircraft to Be on Display During Meetings at Wichita Municipal Airport.

THE DATE OF THE Sixth Annual Personal Aircraft Meeting has been changed from April 28–29 to April 29–30 so that the technical sessions may be held on Saturday to permit a larger number of aeronautical engineers in the Wichita plants to attend the meeting without interfering with company duties. During the two days of the meetings, the latest in personal planes will be demonstrated at the Wichita Airport.

▸ **Dr. Furnas to Speak**—Guest speaker at the I.A.S. Dinner at the Hotel Allis on Friday evening, April 29, will be Dr. C. C. Furnas, Director of the Cornell Aeronautical Laboratory, Inc., who will talk on the subject of "Research for Aircraft Safety."

Dr. Furnas, who has been directing the Cornell Aircraft Safety Program (AERONAUTICAL ENGINEERING REVIEW, page 6, December, 1948), will talk on the findings of the Cornell research as applied to personal planes.

Luncheon Speaker: *Dr. C. C. Furnas, Director of the Cornell Aeronautical Laboratory, Inc., to speak on "Research for Aircraft Safety."*

▸ **Technical Papers**—The Technical Sessions start Saturday morning at 9:00 a.m.; continue to noon, when Luncheon will be served; and resume in the afternoon at 2:00 p.m.

The luncheon speaker will be Duane Wallace, President, Cessna Aircraft Company, whose topic is "The Outlook for the Personal Airplane."

The following papers will be given:

- "The Beechcraft Twin-Quad Power Plant"—J. W. Massey, Beech Aircraft Corporation.
- "The Problem of Stick Force Per G"—T. A. Wells, Vice-President and Chief Engineer, Beech Aircraft Corporation.
- "Boeing's Gas Turbine and the Light Airplane," S. D. Hage, Wichita Division, Boeing Airplane Company.
- "Development of the Anderson-Greenwood 14"—Marvin Greenwood, Vice-President—Engineering, Anderson, Greenwood & Company.
- "Requirements of Army Field Forces for Commercial Model Aircraft"—Major David G. Cogswell, Air Division, Development Section, Army Field Forces.
- "Analysis of the Economics and Utility of Personal Airplanes"—E. W. Norris, Flight Safety Foundation, Inc.

Wichita Host: *Elton H. Rowley, Chairman of the I.A.S. Wichita Section, will welcome Institute members to the Sixth Personal Aircraft Meeting at Wichita this month.*

Plans and organization of the meeting are being worked out by the I.A.S. Wichita Section Chairman, Elton H. Rowley, Chief of Engineering, Flight Test, Boeing—Wichita, and Kenneth Razak.

Mr. Rowley will act as host at the meeting.

National Meetings Calendar

April 29–30	Personal Aircraft Meeting, Wichita, Kan.
May 24–26	I.A.S.-R.Ae.S. Conference, New York
July 21–22	Annual Summer Meeting, Los Angeles

For details see page 102

Plan Twenty-Three British-American Papers for Joint Meeting at Astor, May 24–26

Suggested Tour and Technical Programs Drawn up by Arrangements and Program Committees for I.A.S.-R.Ae.S. Meeting in New York; 12 British and 11 American Papers Tentatively Scheduled for Sessions Beginning Tuesday Morning and Ending Thursday Afternoon.

COORDINATING OVER MORE THAN 3,000 MILES of space with their opposite numbers in the Royal Aeronautical Society through Capt. J. Laurence Pritchard, Secretary of the R.Ae.S., the Institute's Arrangements and Program committees, headed by Preston R. Bassett and T. P. Wright, have set up tentative tour and technical paper schedules that augur well for the success of the historic meeting.

Wheels of the meeting will be set in motion with a reception of the British delegates and their wives by the Institute Council in the evening, May 23, at 2 E. 64th St., followed by a supper. The technical sessions begin in the morning of the next day, Tuesday.

▶ **Tour Arranged**—At the close of the technical sessions, to be held in the Astor Hotel, a dinner is scheduled in the hotel. On Friday, a tour of three Long Island aircraft plants has been planned for the day, to be followed by a "smoker" in the evening.

On Saturday, May 28, a demonstration of the Sperry "blind landing system" is planned, and a luncheon will be served at the Aviation Country Club at Hicksville, L.I., after which a flying meet and personal aircraft exhibit will be held there. Over the long holiday weekend several country places are also to be available for the entertainment of our British guests.

On Tuesday, May 31, the group will inspect American Airlines facilities at La Guardia Field, following which the party will be flown by American to Andrews Air Force Base, headquarters of M.A.T.S., for inspection of the field. A State Department reception is planned for the same day, and a sight-seeing tour of Washington in cars provided by Washington Section members.

Under the auspices of the Washington Section, a dinner will be held to conclude the first day of the grand tour, at which Civil Aeronautics Administrator Delos Rentzel will make the principal speech.

The next morning the British guests and I.A.S. representatives will be flown to Langley by M.A.T.S. for an inspection of the National Advisory Committee for Aeronautics establishment. The next day, they will be flown by the Navy to Patuxent River Naval Air Station. After inspecting the test center and eating lunch, the party will fly to the Naval Aircraft Factory at Philadelphia, returning to New York that night. On Friday, June 3, it is planned to visit Curtiss-Wright plants in New Jersey. A Council Reception and Dinner Friday night will conclude the day's activities.

▶ **Tour Wind-Up**—Final events on the program will be a visit to the Special Devices Center at Sands Point, L.I., Naval Air Station, where luncheon will be served, and in the afternoon the party will go to La Guardia Field at the invitation of Pan American World Airways to inspect the Dehmel Flight Simulator. "Flights" will be made to demonstrate the device by which Pan American flight crews are checked out on Boeing Stratocruisers, now being placed in service over P.A.A. routes.

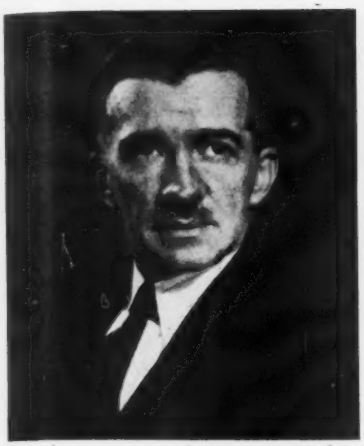
Papers Scheduled for Joint Conference

The British papers to be presented at the technical sessions, which start on Tuesday, May 24, include the following:

- "The Propeller Gas Turbine in Service," by F. M. Owner, Chief Engineer, The Bristol Aeroplane Company Ltd.
- "Turbine-Engined Transport Aircraft," G. R. Edwards, Vickers-Armstrong.
- "Research on Helicopters at the R.A.E. with Special Reference to the Stability of Multi-Rotor Helicopters," H. B. Squire, Royal Aircraft Establishment.
- "Aircraft Materials from the Designer's Point of View," A. E. Russell, The Bristol Aeroplane Company Ltd. (who did the engineering for the Brabazon).
- "The Application of Materials from the Manufacturers' Point of View," Major P. L. Teed, Vickers-Armstrong.
- "The Life of Aircraft Structures," H. A. Wills, C.I.S.R., Australia.
- "Some Considerations of the Flutter Problems of High Speed Aircraft," E. G. Broadbent, Royal Aircraft Establishment.
- "The Relative Merits of Auxiliary Power Systems: The Hydraulic Aspect," by H. G. Conway; "The Electrical Aspect," R. H. Woodall, and "The Pneumatic Aspect," H. R. Haerle.
- "The Relative Efficiencies of Large Landplanes and Flying Boats," D. Keith Lucas, Short Brothers and Harland.
- "Operating Factors Affecting the Design of Future Civil Transport Aircraft," Christopher Dykes, British Overseas Airways Corporation.

American papers scheduled are:

- "Optimum Fields of Applications for Air-Consuming Aircraft Power Plants," by W. G. Lundquist, Wright Aeronautical Corporation.
- "Recent Design Refinements in Turbojet Engines," N. Burgess and J. C. Buechel, Aircraft Gas Turbine Division, General Electric Company.
- "Operational Experience with Helicopters," Clarence M. Belinn, President, Los Angeles Airways, Inc.
- "Aircraft Materials in the U.S.," Clyde Williams, Battelle Institute.
- "American Structural Design Trends," G. G. Green, Chief Structures Engineer, Consolidated Vultee Aircraft Corporation.
- "Aerodynamically Boosted Surface Controls as Applied to the DC-6 Transport," Orville R. Dunn, Douglas Aircraft Company, Inc.
- "Aeroelastic Problems at Supersonic Speeds," A. H. Flax, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc.
- "Résumé of High-Speed Aerodynamics," Walter Vincenti, Ames Aeronautical Laboratory, N.A.C.A.
- "Transonic Aerodynamic Results from Flight Testing of Dropped Bodies and Rocket Models," Floyd L. Thompson, Chief of Research, Langley Aeronautical Laboratory, N.A.C.A.
- "The Utilization Factors and Maintenance of Civil Airplanes," Warren Alberts, United Air Lines, Inc.
- "Aerodynamic Efficiencies of Large Landplanes," G. S. Schairer, Staff Engineer, Boeing Airplane Company.



Spark Arrangements and Technical Programs: *Preston R. Bassett, Chairman of the Arrangements Committee (left) and T. P. Wright, Chairman of the Program Committee, have headed the committees' efforts in diligently drawing up the schedules and events for the second joint meeting of the Institute and the Royal Aeronautical Society.*

Kimball Succeeds Brown in Naval Post

Dan A. Kimball, an Associate Member, and Executive Vice-President of the Aerojet Engineering Corporation, Azusa, Calif., was appointed February 11 to succeed John Nicholas Brown as Assistant Secretary of the Navy for Air.

Mr. Kimball, a veteran of World War I, who was trained as a pilot in the same group as James H. Doolittle, is 52. In addition to his position in Aerojet Engineering, he was a Vice-President and Director of General Tire & Rubber Company. He replaced Mr. Brown in the second week of March.

Mr. Brown, who has been Assistant Secretary of the Navy for Air since 1946, is a banker whose home is in Newport, R.I.

Most Power-Plant Failures Due to Fuel System Breakdown, Weick Report Shows

Fred E. Weick, Director of the Personal Aircraft Research Center, Agricultural & Mechanical College of Texas, and I.A.S. Fellow, has announced the findings of "An Analysis of Personal Airplane Power-Plant Failures During 1947 with Some Suggested Remedies," in which a study has been made of approximately one-seventh of the total of 9,253 nonair-carrier accidents recorded by the Civil Aeronautics Board for 1947. Figures in it show that two-thirds of the recorded accidents and seven-eighths of those of known cause were caused by some failure of the fuel system. The information includes all recorded power-plant failures for engines up to 200 hp. leading to accidents involving at least major damage.

▶ **Analysis Surprising**—Terming the findings of this analysis as surprising, Mr. Weick said it was hoped that some of the obvious remedies will be acted upon toward further increase of power-plant reliability. The improvements indicated, he declared, can be accelerated "if they are demanded by personal plane users and by the dealers who represent them to the manufacturers."

A brief recapitulation of the failures cited in the report shows the following:

Fuel system	920
Engine structure	53
Lubricating system	47
Propeller assembly	19
Ignition system	18
Control system	12
Miscellaneous	5
Engine accessories	3
Total determined	1,077
Total undetermined	276
Total	1,353

▶ **Remedies Suggested**—Most likely remedies for these failures, Weick said, may be grouped in the following four classifications:

- Duplication of system (such as twin-ignition, fuel, or lubrication system).
- Change in basic method (such as change from carburetor to fuel injection system or elimination of item giving trouble).
- Use of fuel system giving unmistakable warning when 1 hour of fuel is left and accurate indication of fuel quantity thereafter.

Where none of the above-mentioned remedies is applicable, the only apparent one remaining is

- Improved detail design, construction, or maintenance.

More than half of the determined power-plant failures (549 out of 1,077), the report says, could have been prevented by the use of a properly functioning fuel injection system in place of a carburetor. Of the rest, one-third might have been prevented by duplication of the system.

N.F.P.A. Committee Meeting in San Francisco May 18

A meeting of the National Fire Protection Association Committee on Aviation and Airport Fire Protection is to be held May 18 at the Fairmont Hotel, San Francisco, it was announced by George H. Tryon, III, Committee Secretary and I.A.S. Associate Member.

At the meeting, which is open to anyone having an interest in the work of the Committee, the Committee's recommendations on "Aircraft Rescue and Fire Fighting Equipment for Airports" (*Bulletin No. 18*) and its recommendations regarding the "Hazards of Static Electricity in Aircraft Maintenance, Servicing and Operation" (*Bulletin No. 14*) will be submitted for final adoption.

Dixie Journal to Promote Engineering Research in South

With the rapid acceleration in the development of engineering and research installations in Dixie since World War II, a new scientific journal devoted exclusively to the South is being published by the Southeastern Research Institute, Inc., 5009 Peachtree Rd., Atlanta, Ga.

Called the *Journal of Southeastern Research*, it shows the combined results of the efforts of Southern scientists. A quarterly publication, it is edited by H. McKinley Conway, Jr., an I.A.S. Member, native Southerner and graduate of Georgia Institute of Technology.

According to Mr. Conway, the general objective of the *Journal* is to encourage and promote engineering research in the Southeastern United States.

Other objectives include:

- Furnishing wider recognition of the work of Southeastern scientists.
- Working for improvement of opportunity for the individual scientist in the Southeast.
- Seeking greater public and private support of scientific research in the region.
- Encouraging closer cooperation between science and industry in the area.
- Providing means by which Southeastern scientists may exchange ideas and achieve unity of thought and action when needed.

The *Journal* covers engineering research activites in eleven Southeastern

Last Chance for Roster Listing

In order that the 1949–1950 I.A.S. Roster of Members be as complete and accurate as possible, a last call is being issued by the Membership Department of the Institute for latest data concerning present employment and titles, company addresses, and preferred mailing addresses of more than 7,000 members.

This is your last opportunity to be correctly listed in the 1949–1950 I.A.S. Roster of Members. Some members have failed to send in their completed roster cards, and for this reason we have extended the original deadline date to **April 30, 1949,** after which no further returns can be accepted. Make sure that the roster card which was previously mailed to you for completion is filed before that date.

states from Virginia to Texas. News items of special interest to southeastern research men and technical papers may be submitted to the Editor, who acts with the advice of a group of Southeastern scientists. For information as to preparation of papers, write to the Editor.

I.A.S Newslines

▶ In Dallas Office . . . **Paul S. Baker,** Engineering Manager of Chance Vought Aircraft, has moved from Stratford, Conn., to new office in Dallas. Present address of Mr. Baker, a Fellow, is: Chance Vought Aircraft Division, United Aircraft Corporation, P.O. Box 5907, Dallas, Tex.

▶ Giannini Vice-President . . . **Charles H. Colvin** has been elected Vice-President of G. M. Giannini & Co., Inc. Mr. Colvin, a Fellow, who has been identified with the aircraft instrument development since 1914 and was a founder of the Pioneer Instrument Company, has been associated with Sperry Gyroscope and Kollsman Instrument. He will be in charge of the eastern plant of Giannini at 697 Morris Turnpike, Springfield, N.J., which was just established.

▶ Task Fleet Commander . . . **Vice Adm. Donald B. Duncan,** U.S.N., is now Commander, Second Task Fleet, Norfolk, Va. He formerly was Deputy Chief of Naval Operations, Air. Admiral Duncan is an Honorary Member.

▶ Designer with Bristol . . . **A. W. Fraser,** Associate Fellow, has accepted an appointment as a Designer with The Bristol Aeroplane Company Ltd. He has moved from Ayrshire, Scotland, to Redcliffe House, Old Church Road, Uphill, Weston-super-mare, Somerset, England.

▶ Returns to Sperry . . . **Reginald E. Gillmor,** Associate Fellow, resigned as Vice-Chairman of the National Security Resources Board, where he has served since September, 1948, and has returned to The Sperry Corporation as a Vice-President. He previously had been Vice-President for Public Relations.

▶ Consultant . . . **Robert Insley,** a Fellow and Engineering Vice-President of Continental Motors Corporation, Detroit, has been named Consulting Engineer by Foley & Company, 15 Park Row, New York City. He is retaining his post at Continental Motors, devoting part of his time to important development work with Foley & Company. A former President of the S.A.E., he is one of the best known persons in the field of aircraft power-plant engineering.

▶ Industry Representative . . . **James H. "Dutch" Kindelberger,** Chairman of the Board of North American Aviation and I.A.S. Fellow, has been appointed representative of the aircraft industry on a new committee organized to recommend which plants and equipment now held by Government in National Industrial Reserve should be retained for commercial use. Committee is working closely with Munitions Board and makes recommendations to the Secretary of Defense.

▶ Leaves Texas . . . Associate Fellow **Robert M. Pinkerton,** who has been teaching at Texas A. & M. since 1941, returned home in Hampton, Va., the end of January to accept an appointment as Aeronautical Research Scientist with the N.A.C.A., Langley Field, where he will work on transonic aerodynamics.

▶ I.R.E. Convention Speaker . . . **Delos W. Rentzel,** Civil Aeronautics Administrator, was a featured speaker at the Institute of Radio Engineers' Convention held at the Hotel Commodore, New York City, March 8. Mr. Rentzel, an Honorary Member, spoke on "All Weather Flying."

▶ Dean of Technology . . . The President and Regents of the University of Minnesota have announced the appointment of **Athelstan F. Spilhaus** as Dean of the Institute of Technology. An Associate Fellow, Mr. Spilhaus was Director of Research, College of Engineering, New York University.

▶ Presented Hawks Award . . . **Gen. Hoyt S. Vandenberg,** Honorary Member, Air Force Chief of Staff, was presented with the Frank M. Hawks Memorial Award "for leadership in military aviation" at the dinner of the Air Service Post 501, American Legion, in New York.

At Last, A Listener's Friend

The "listener's friend"—the ingenious device (shown below) displayed by R. Dixon Speas to Major R. R. Hajek, proved to be a main attraction at the afternoon Air Transport Session of the recent I.A.S. Seventeenth Annual Meeting held in New York. Cooked up by Dix Speas and produced by the radio engineers of American Airlines, the gadget serves to remind speakers when to stop talking.

A time-clock dial is set for any given time allotted the speaker, and a green light remains on during this interval.

ABLE MABEL GOES ALOFT

A Martin AM-1 Mauler, Navy's largest, fastest, most heavily armed carrier-based dive-torpedo bomber goes aloft with a pay load of more than 9,000 lbs. including three full-sized torpedoes, twelve 5-in. rockets and four 20-mm. cannon. As photographed, gross weight is 25,520 lbs.—it can fly at an all-up weight of more than 29,000 lbs. with a pay load of almost 6 tons. The Mauler is powered by the 3,000-hp. Pratt & Whitney Wasp Major. About one-third of the 149 Maulers originally ordered by the Navy were yet to be delivered as we go to press.

Two minutes before the expiration of such time, a yellow caution light comes on. The final fireworks take place when the time is up and is evidenced by the appearance of a red light, which warns the speaker to either sit down or suffer the consequences. In this particular instance, Mr. Speas served warning to all speakers that the gadget was hooked up with the hotel fire-alarm system, which would automatically sound off if the red light were allowed to burn longer than 1 min.

Doubtlessly, this device will serve many other useful purposes in the future. (With slight variations, it could even be adopted to home use, shutting off everything from the cook-stove to the wife.)

Corporate Member News

• 5,000th Allison Turbojet Delivered . . . The 5,000th turbojet engine was delivered by **Allison Division,** General Motors, to the Air Force on February 18. Present production models develop 5,400 lbs. thrust at take-off with water/alcohol injection. Normal rating is 4,600 lbs. Also, 300 hours' operation is now permitted between overhauls. No. 1 engine delivered was rated at 3,725 lbs. thrust with 25 hours between overhauls.

• By-Product . . . The record cross-country flight of 3 hours 46 min. by the XB-47 Stratojet, out of **Boeing Airplane Company's** stable, at an average speed of 607.8 m.p.h., was "a routine one rather than a record attempt," explains 29-year-old Major R. E. Schleeh, Deputy Chief of Bomber Operations, A.M.C., who piloted the jet bomber. "We set up a long-range cruise condition that would give us the most economical use of our fuel. The flight that resulted was a by-product of this planning," he said.

• Net earnings of $3,378,123 in fiscal 1948 were announced by **Continental Motors Corporation** and its consolidated subsidiaries, equal to $1.02 per share of common. It compared with a net loss of $1,292,874 in the preceding year.

• An order for 14 sets of Model 3430 floats for delivery to the Air Force was received by **The Edo Corporation** through Cessna Aircraft. Floats have been bought for installation on the Cessna LC-126A utility aircraft designed for Air Force rescue operations in Alaska.

• Continenal Licensed for Al-Fin Process . . . **Fairchild Engine & Airplane Corporation** announced the signing of an agreement covering use of its Al-Fin bonding process by Continental Motors Corporation. Continental will use the process in making a new series of lightweight air-cooled gas engines to power Army tanks, gun carriers, trucks, and other ordnance vehicles.

• **Fairchild Camera & Instrument Corporation** has a new universal mount for its Oscillo-Record Camera, which is widely used for recording cathode-ray oscilloscope images. According to the company, new mount eliminates need for extra standard mounts when the camera is to be used with several different oscilloscopes, since it supports camera and periscope without attachment to the oscilloscope, and the entire assembly therefore can be moved as a unit from one instrument to another. Mount is adjustable in height to suit any standard oscilloscope.

• New Flight Recorder . . . A new-type flight recorder that automatically records air roughness, altitude, and automatic pilot operation has been developed by **General Electric Company.** It is so accurate in recording altitude, G-E says, that changes as small as 10 ft. are recorded . . . First J-47 jet engine to be produced in the Lockland plant passed its first tests and was accepted by the Air Force some weeks ago . . . Greatly expanded repair, maintenance and warehousing facilities are to be established in Salt Lake City. New facilities will increase by nearly 50 per cent the warehousing space and will more than double capacity for service and repair of motors, transformers, control devices, and assembly of special switchgear.

• 30th Birthday . . . Thirty years of pioneering in the development and production of aircraft props are being celebrated this year by **Hamilton Standard Propellers Division,** United Aircraft Corporation. One of the oldest companies in continuous existence in aviation, Hamilton Standard started out in a two-story garage in Pittsburgh, Pa.

• Completes New Steel Plant . . . Completion of a $500,000 plant expansion program for **Lebanon Steel Foundry,** Lebanon, Pa., doubles company's high alloy steel casting facilities for production of super-alloy castings under secret processes developed by Firth-Vickers Stainless Steels Ltd., leading British steel casting concern. Lebanon Steel is licensed to use the process.

• Disappearing Rocket Mount . . . Rockets will become standard equipment on U.S. Air Force jet fighters as a result of the successful development of a new disappearing rocket mount, according to **Lockheed Aircraft Corporation.** New mounts give thin-winged jets the extra fire power but do not affect the planes' speed or maneuverability after rockets are fired. Mounts retract into the wing when last rocket is fired . . . Year-end backlog of orders amounted to $195,900,000, according to Robert E. Gross, President, who added that 1948 operations were characterized by return to profitable operations, retirement of bank indebtedness, and increase in the order backlog. Of the total, $14,500,000 was for commercial Constellation transports.

• Banshee Order to Be Completed in 1950 . . . Deliveries of the F2H-1 Banshee, Navy's newest operational jet fighter, will continue at an accelerated pace through 1949. Entire order for 235 is scheduled for completion by June 30, 1950, **McDonnell Aircraft Corporation** says.

BEETLE AND THE ELEPHANT

Like a beetle underneath an elephant, the world's smallest airplane is overshadowed by the world's largest. Beneath the vast bulk of Consolidated Vultee Aircraft's XC-99 troop transport, which weighs 265,000 lbs., is the tiny 360-lb. Wee Bee. The Wee Bee, built by three Convair employees in their spare time, is powered by a 22-hp., two-cylinder engine and carries 2 gal. of fuel. The 15-ft. Wee Bee is 4 ft. shorter than the 19-ft. dia. propellers on the XC-99. Wing span of the small plane is 15 ft., compared to the giant's 230-ft. span.

• Services Buy Electronic Fuel Gage . . . **The Minneapolis-Honeywell Regulator Company** has received orders for supplying a new electronic fuel gage for Navy and Air Force jet fighters. It will be the first use of the fuel gage on fighter aircraft, company said, although it is standard equipment on a number of bombers and commercial aircraft. Contracts amount to $400,000.

• Northrop Building 48 F-89's . . Preparations for production of F-89 all-weather fighters, 48 of which have been ordered from **Northrop Aircraft, Inc.,** by Air Force, are well under way. Production design is under supervision of C. W. Harris, Project Engineer.

• Receives Second Stratocruiser . . . Its second Boeing Stratocruiser was received by **Pan American World Airways** on February 17. Two more were being readied by Boeing for delivery in the following 2 weeks.

• Two New Thunderjets . . . Two new models of **Republic Aviation Corporation's** Thunderjets, the F-84D and E, reflect the number of major changes in performance and maintenance qualities due to operational experience in the field and production improvements in the factory. The F-84D has been in production for several months. Major improvements include reinforcement of metal skins on wings and ailerons, winterized fuel systems, changes to permit gasoline instead of kerosene operation, and substitution of mechanical instead of hydraulic shrinkage of landing gear.

• Rohr Acquires Plant . . . **Rohr Aircraft Corporation** has acquired a portion of its wartime plant at Chula Vista, Calif., from War Assets. Monthly rental fee is $5,132 for 13 acres, including six buildings with combined floor space of 250,000 sq.ft. Rohr is using property for production of military equipment under Air Force contract.

• World-Wide Petroleum Research . . Record budgets totalling $24,000,000 have been adopted by **Shell Oil Company** for world-wide petroleum research during 1949. Huge sum is intended to finance research in all phases of operations, from seeking new sources of crude oil to improving fuels, lubricants, and chemicals . . . Shell graduate fellowship program established in the U.S. will continue through the 1949-1950 academic year, Shell Fellowship Committee announced. Fellowships have been established in chemistry, geology, geophysics, and physics.

• Sikorsky Rotor Test Stand . . . A new 1,200-hp. main rotor electric test stand, only one of its kind in the country, has been completed by **Sikorsky Aircraft Division,** United Aircraft, for testing performance, endurance, and balance of rotor heads and blades. The concrete-imbedded, 26-ft. high stand is a semimonocoque (cone-shaped) structure, encircled by a 5,000-sq.ft. protective fencing. It can manage 90-ft. main rotor discs if ever needed. The ingenious and highly technical project (directed by I.A.S. Fellow Michael Gluhareff, I.A.S. Member Harry T. Jensen, and others) has taken more than a year to complete. Execution of project has been in hands of Jensen, who was in charge of specifications. Igor I. Sikorsky, Honorary Fellow, drew up methods of suspension which isolate all the forces to be measured. Stand is designed to withstand loads up to 45,000 lbs. of vertical thrust, 90,000 lbs. of side force at top of stand, and 107,000 ft.lbs. of torque.

• To Expedite Cargo Shipments . . . A new interchange agreement has been signed by **United Air Lines** and Trans-Canada Air Lines to expedite Canadian–U.S. air cargo shipments. Under agreement, the air lines will honor each other's airbills without rebilling on shipments passing between all points on United's 80-city system and cities on the coast-to-coast Canadian route of T.C.A. Transfer of cargo will take place at Vancouver, Chicago, Detroit, Cleveland, New York, and Boston . . . U.-A.L. this year is devoting full attention to perfecting operational use of VOR, or VHF Omni-Directional Range navigation system.

• Radio Tube Weight Cut in Half . . . By adapting an idea that lightened warplane engines, **Westinghouse Electric Corporation** engineers have cut the weight of a giant radio broadcasting tube by 56 per cent. Success of aluminum cooling fins for aircraft engines suggested their tryout in radiators of transmitting tubes. As a result, 25,000-watt tubes with laboratory-built aluminum radiators weigh only 98 lbs. instead of conventional 225 lbs. with copper radiators.

• Delivers First Cyclone 7 . . . **Wright Aeronautical Corporation** delivered the first Cyclone 7 engine to be produced under a $7,000,000 order received last summer. The 800-hp. engine, smallest in the Cyclone series, is receiving prop stress and nacelle shakedown tests. Later it will go to North American for installation in the T-28 trainer . . . Wright will flight-test its Turbo-Cyclone 18 (R-3350) compound engine this summer. Delivery of production engines to the Navy is scheduled for early 1950.

News of Members

D. G. Andreoli is with Chance Vought Aircraft Division, United Aircraft Corporation, in Dallas, Tex., as Flight Test Liaison.

Robert O. Bitner recently accepted a position with the Civil Service at Wright Field, Dayton, Ohio, as an Aerodynamic Development Engineer, Grade P-3.

Given A. Brewer, formerly in Charge of Research & Development, E. Anthony & Son, Inc., New Bedford, Mass., is now Manager, Massachusetts Airlines.

Charles E. Burns has returned to Lockheed Aircraft Corporation as a Sales Engineer from Baumann Aircraft Corporation, Burbank, Calif., where he was an Engineer.

Horace H. Cherry, former Preliminary Design Group Engineer with Douglas Aircraft, has been Assistant Professor and Research Assistant at Texas A. & M. College since December 27, 1948.

Lewis H. Chow is with Canadair Ltd., Montreal, Quebec, as Experimental Engineer. New address is 3170 Van Horne Ave., Montreal, Quebec, Canada.

H. V. Cooper, Jr., left The Glenn L. Martin Company, where he was a Flight

Test Group Engineer, and is doing the same type of work at Northrop Aircraft, Inc., Hawthorne, Calif.

Thomas J. Cotton, Jr., formerly a Design Engineer with Westinghouse Electric, Lester, Pa., has been appointed a Designer at Douglas Aircraft, Santa Monica. New address is Mountain View Inn, 1930 Stewart Ave., Santa Monica, Calif.

Lt. Herman L. Delaune, U.S.A.F., has been assigned as an Air Installations Engineer since last November at Dayton, Ohio.

Joseph C. DeWeese has moved from Baltimore, Md., to Columbus, Ohio, where he is Senior Design Engineer, Power Plant Design Section, Engineering Department, Curtiss-Wright Airplane Division. He had been Head of Power Plant Operations Group, Engineering Division, The Glenn L. Martin Company.

Walter M. Fitch has transferred from Engineering Laboratories, Boeing Airplane Company, Wichita, to Service Engineering, Unit Publications.

Pauline V. Glazier is now with Hughes Aircraft Company as an Engineer in Guided Missiles. She formerly was with Boeing—Seattle, Plant 2, as Research Laboratory Analyst.

Albert D. Glowinski has changed his name to Albert D. Glowe. He is Foreign Sales Manager and Assistant to the Vice-President, Kearney & Trecker Corporation, Milwaukee, Wisc. Address is 2 Sutton Place, So., New York 22, N.Y.

Robert C. Gordon is Junior Development Engineer for Goodyear Aircraft Company, working on lighter-than-air ships.

Brad J. Griffen, formerly Layout Draftsman for Chance Vought Aircraft, is now Senior Designer for Goodyear Aircraft Corporation. His new home is in Akron, 1936 16th St., N.W.

Donald F. Heyman is Engineering Draftsman A with Consolidated Vultee Aircraft Corporation, San Diego Division.

Donald Herr, formerly Executive Engineer, Allen-Bradley Co., Milwaukee, is now with the Reeves Instrument Corporation, New York City, as Project Engineer.

Clarence S. Howell, Jr., is an Engineer with the Propeller Division, Curtiss-Wright Corporation.

Paul R. des Jardins is a Draftsman with Chase Aircraft Company, Inc. New address is 2076 Pennington Rd., Trenton, N.J.

Robert W. Johnson, formerly Junior Engineer with Shell Oil in Martinez, Calif., is now Aeronautical Research Scientist P-2 with N.A.C.A. at Moffett Field. New address is 668-B Sierra, Mountain View, Calif.

Charles E. Kahlke, Jr., is engaged in his own private engineering business firm's practice in Jamestown, N.Y. New address is 34 Grant St., Jamestown. He formerly was a draftsman with the Marlin Rockwell Corporation in Jamestown.

Henryk Kestenberg of 4 Gnessin St., Tel-Aviv, Israel, Palestine, is an engineer of the Aero Club of Palestine in Tel-Aviv.

Robert B. Lea is no longer connected with Sperry Gyroscope Company, having transferred to The Sperry Corporation for special work in coordinating certain activities of the divisions.

Lt. Col. T. H. Lin is Head of the Technical Mission in England, Chinese Air Force.

Jack E. Linden has been promoted to post of Head, Performance Analysis Section, Aerodynamics and Hydrodynamics Branch, Bureau of Aeronautics, Navy Department.

J. Lucasiewicz is a Research Engineer for the National Research Council, Ottawa, Canada.

Kenneth Mann resigned as Chairman, Aerodynamics Department, Cal-Aero Tech, to become Structural Engineer with Hughes Aircraft Company, Culver City, Calif. He lives at 7412¼ Arizona, Los Angeles 45.

Andrew C. McDermott is a Stress Analyst with Boeing Airplane Company, Seattle.

Necrology

George J. Mead

George J. Mead, a Founder Member of the Institute of the Aeronautical Sciences, and one of the cofounders of Pratt & Whitney Aircraft, died following a long illness at his home in Bloomfield, Conn., on January 20.

Dr. Mead was internationally known in the field of aircraft engine design, having directed the design and development of the original line of Pratt & Whitney engines. He retired in 1939 when he was Vice-President and Chief Engineer of United Aircraft Corporation.

▶ **50,000-Plane Program**—In 1940, following President Roosevelt's call for 50,000 planes a year, Dr. Mead came out of retirement to serve as an assistant to Secretary of Treasury Morgenthau in getting the program under way.

With William S. Knudsen, of General Motors, he established the aeronautical section of the National Defense Committee in Washington, D.C. For this work he was presented with the President's Medal of Merit by Major Gen. E. M. Powers, representing the Chief of Staff, U.S.A.F., last June.

Gifted with the exceptional ability to analyze designs and engine test data, he could select from them the combinations most likely to succeed. His long experience and discerning judgment enabled him to chart a course for aircraft-engine procurement through allied industries, entirely removing the fear that engines would become a bottleneck in building a greatly enlarged air force in a short time.

Dr. Mead was an Honorary Fellow of the Institute.

Albert W. Conover

Albert W. Conover, Jr., Project Test Pilot, North American Aviation, lost his life when the XAJ-1 he was test flying crashed in the ocean off Los Angeles on February 4.

▶ **Tested F-86**—He came to North American in 1947 from Ryan Aeronautical Company, where he was Director of Flight Test. At North American he was project pilot on the XFJ-1 and FJ-1 and carried out demonstrations of the FJ-1 for the Navy at the Patuxent River, Md., test center. He also conducted tests on the XF-86 and F-86A at the company plant.

Educated at the University of Colorado, School of Engineering, from 1938–1940, he joined The Glenn L. Martin Company, Baltimore, as a draftsman in 1940. Subsequently, he went to Bell Aircraft as a liaison engineer on the P-39 and P-65 aircraft. Parks Air College appointed him a flight instructor, and Curtiss-Wright later made him test pilot on the XA-25, SB-2C, XC-46, P-40, B-17, B-24, and B-29 at Curtiss factories and modification centers.

Lt. Gordon McHenry, U.S.A.F., is stationed at Keesler Field, Miss.

Major G. J. McTigue, U.S.A.F., is on active duty at Hq. Military Air Transport Service, Andrews Air Force Base, Camp Springs, Md., where he is Chief of Engineering Projects. He had been with Panagra, at Limatambo, Lima, Peru.

Squadron Leader J. L. Mitchell, R.A.F., who returned to England in the fall of 1947 from Washington, had a spell of duty as Development Navigation Officer at the Central Bomber Establishment, R.A.F., at Marham Norfolk, where he was present for the arrival of some B-29's of the Third Air Division. He now is posted to the R.A.F. College, Cranwell, Lincolnshire, as Senior Navigation Instructor.

William J. Mleczko is a Flight Test Engineer at Air Materiel Command, Wright Field. He had been with N.A.C.A., Langley Field.

Robert A. Needham has changed his address from Inglewood, Calif., to Box 129, California State Polytechnic College, San Luis Obispo, Calif., where he is an Instructor in Aeronautical Engineering.

Leonard C. Peskin is President of Thermal Research & Engineering Corporation, Philadelphia, Pa. He was Manager of Kellett Aircraft during its period of trusteeship, and earlier, its Vice-President.

John Leith Potter resigned as Instructor of Aeronautical Engineering at University of Alabama to become Aerodynamicist A with North American Aviation, Inc., and lives in El Segundo, Calif., Box 2261.

Abner Rasumoff is now with Hughes Aircraft Company, Culver City, Calif. He was with Kellett Aircraft Corporation as a Project Stress Analyst. New address is 4029 West Blvd., Crenshaw Village, Apt. D, Los Angeles, Calif.

Henry W. Roberts has been elected a Director and Vice-President of International Industrial Corporation, New York City, which is engaged in export of aeronautical materials and supplies, chiefly to France and colonies. He is author of *Aviation Radio.*

Frederick W. Ross, Assistant Director, Aeronautical Research Center, University of Michigan, has been appointed a member of the Panel on Countermeasures, Committee on Guided Missiles, Research & Development Board. This activity will take only part of his time, and he will carry on with his usual duties at Willow Run.

Walter H. Setz, formerly with the Cornell Aeronautical Laboratory, is now Project Specialist with the U.S. Naval Air Development Station, Johnsville, Pa.

Rodney H. Smith, former Assistant Professor, M.I.T., is now a Consultant for the Operations Analysis Section, Hq. Strategic Air Command, Ft. Crook, Neb.

John W. Steffen is now employed as Mechanical Engineer P-2 with N.A.C.A. at Moffett Field. He had been with United Air Lines at San Francisco. Home address is 1124 Kilarney Lane, Burlingame, Calif.

William B. Terry has moved from Canada to 109 N. Chatsworth Ave., Larchmont, N.Y. He is an Engineer, Tool Engineering, Grumman Aircraft Engineering Corporation.

John W. Thorp was appointed Chief Engineer of Aviation Maintenance Corporation. Thorp is the founder of Thorp Aircraft Corporation, and for 6 years was assistant chief of preliminary design at Lockheed Aircraft. Also during his 20 years in the industry, he served 6 years as instructor of engineering at the Boeing School of Aeronautics.

Harrison W. Toy is a Draftsman with Chase Aircraft Company, West Trenton, N.J. His address is 303 Hazel Avenue, Delanco, N.J.

Lt. Comdr. G. T. Weems, U.S.N., has been ordered to England for duty at Empire Test Pilots School, Farnborough, Hants. He had been at Patuxent River, Md., at the Naval Air Station Flight Test Center.

H. S. Wilburn has been named Inspector, Flight Test, Boeing Airplane Company, Seattle. He was at The Aeronautical University in Chicago.

Robert Wilhoit is a Junior Engineer with Boeing Airplane Company, Seattle.

Meet Your Section Chairmen

George Dawson Ray

Buffalo Section

As far back as George Ray can remember he wanted to be an aeronautical engineer. Biggest impression, aviation-wise, occurred while he was in the eighth grade in Mundelein, Ill., where he was born 34 years ago, when Lindbergh and Byrd flew the Atlantic back in 1927.

▶ **Learns to Fly**—Ray became a pilot himself, learning to fly in 1934–1935. Since then he has flown 22 different types of aircraft in 13 years. In 1936 he received his B.S. in Aeronautical Engineering at Massachusetts Institute of Technology.

His first aviation job was with Douglas Aircraft Company, Inc. (Santa Monica), as an engineer, to which he was appointed soon after his graduation in 1936. In 1940 he joined Curtiss-Wright's Airplane Division at Robertson, Mo., as aeronautical engineer, and in 1941 he was named Project Structures Engineer at Bell Aircraft in Buffalo.

▶ **Rotary-Wing Enthusiast**—In his career so far, Ray has tried a good number of phases of aeronautical engineering, each of which he says seemed more interesting than the last. These include weights, stress analysis, structures testing, air-frame design, controls design, installations design, and testing.

He also has tried many sizes of aircraft, from the XB-19 to the H-13B helicopter, and has become a confirmed rotary-wing enthusiast. A brief (4-hour) period of flight instruction, plus numerous flights to observe operation of test installations, have convinced him that short-range fixed-wing aircraft will be poor competition for the helicopter when means are found to reduce the production cost of the latter.

▶ **Saw Russian Air Power**—While at Bell, Ray flew to Russia in 1943 to observe the Bell P-39 Airacobra in action on the Russian front. While in Russia he discussed its operation with Russian technicians and talked aeronautics with some of the Soviet's top designers. His observations are recorded in an article in *Aviation*, May, 1944, entitled, "I Saw Russia's Air Power," and in a paper given before the Buffalo Section in December, 1948, called "Soviet Aviation in World War II, and Some Postwar Trends."

In addition to the article in *Aviation*, Ray has published one on "Helicopter Controls" which appeared in the June, 1947, issue of *Machine Design.*

Outside of engineering work, building a house, landscaping the grounds, and raising a daughter leave little time for other activities, although he enjoys skiing and swimming in season and flying.

Eugene W. Wasielewski

Cleveland-Akron Section

A liking for mathematics and a fondness for things mechanical led Eugene Wasielewski, hard-working Chairman of the Cleveland-Akron Section, into aeronautics to which he was drawn by the mathematical approach encountered in that dynamic field.

▶ **Musician**—While highly regarded as an exceptionally capable engineer, Eugene Wasielewski is also an accomplished

musician, having spent 2 years in Liberal Arts College and having completed 3 years of college work in music. A pianist, he still turns to music as a favorite means of relaxation.

Born in Milwaukee on July 21, 1912, where he attended the Bay View High School, graduating in 1929, he next went to Marquette University College of Liberal Arts, 1929–1931. In 1931 he switched to the University of Michigan, where he obtained a B.S. in Mechanical Engineering and in Aeronautical Engineering in 1934 and an M.S. (E.M.) in 1935.

His first engineering job, taken in October, 1935, was with Allis-Chalmers Manufacturing Company as a student engineer, working on erection and tests of steam turbines, blowers, compressors, pumps, and motors.

In 1937 he was appointed a Junior Engineer by the National Advisory Committee for Aeronautics at Langley Field, Va., where he worked on design and test of superchargers of the radial- and axial-flow type and did engineering and research on test methods, instrumentation, engine, and supercharger problems. He was promoted to Assistant Engineer.

▸ **Joins Ranger**—Next, he joined Ranger Aircraft Engines Division, Farmingdale, L.I., N.Y., in April, 1941, as Project Engineer. In that capacity he was responsible for the design and construction of supercharger laboratories and tests of superchargers, and supercharger components. He also was responsible for the design of superchargers and related parts, as well as the engineering and related problems.

Stratos Corporation in July, 1943, named Mr. Wasielewski as Executive Engineer, placing him in charge of the Engineering Department, which included responsibility for design, test, drafting, and research for superchargers.

▸ **Designing New N.A.C.A. Laboratory**—His present work, with the Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland, is Project Engineer in charge of designing a new laboratory, the Propulsion Sciences Laboratory, to be built in Cleveland and to be used for testing large engines and their components. An appropriation of $10,000,000 has been authorized for the project. Mr. Wasielewski has been with N.A.C.A. for about 5 years.

It was during his first employment with N.A.C.A. at Langley Field that he designed and constructed, with Eastman Jacobs, what was perhaps the first axial-flow compressor (N.A.C.A. eight-stage axial flow blower) built in this country for aeronautical purposes.

Later, he worked with Andre Planiol at Stratos Corporation in the development of the Szydlowski-Planiol supercharger, a combined axial and centrifugal type.

He also spent several years in the development of Roots-type superchargers for use with gasoline and diesel transportation engines and also as steam compressors and cabin superchargers. In addition, he developed with others an air-turbine-driven pump for use as a water injector on jet engines.

▸ **N.A.C.A. Papers**—Mr. Wasielewski has written for N.A.C.A. publication two papers: "Effect of Supercharger Control Methods on Aircraft Engine Performance and "The N.A.C.A. 8-Stage Axial-Flow Compressor."

In addition, he gave a paper before the Society of Automotive Engineers (Chicago) on "Some Problems Connected with the Supercharging of Diesel Engines."

Besides music, Mr. Wasielewski, who is married and has four children, likes working around his home, swimming, playing tennis, and reading for relaxation.

I.A.S Sections

Baltimore Section

Don K. Covington, Jr., *Secretary*

Following a business session, 75 members attending the meeting of January 12 saw films of the V-2 rocket, a Gorgon missile, and the highly entertaining Air Force film, *Aircraft Oddities*. O. J. Schaefer, Chairman, presided.

On the evening of February 2 at The Johns Hopkins University, members heard Robert Donovan, Project Engineer, Douglas Aircraft Company, Inc., speak on the subject, "Flight Testing the Douglas Skystreak—Douglas Skyrocket." There were 185 present at the meeting with Vice-Chairman G. S. Trimble presiding.

The talk was illustrated with slides and was followed by a 20-min. film of both the Skystreak and Skyrocket. A general discussion from the floor concluded the address.

Cleveland-Akron Section

S. Doree Black, *Secretary*

Abe Silverstein, following a brief introductory by Dr. Edward Sharp, Director of the Lewis Flight Propulsion Laboratory, presented for the second time the Twelfth Annual Wright Brothers Memorial Lecture, "Research in Aircraft Propulsion Systems," at the January 18 meeting. Chairman Eugene Wasielewski presided with 250 members present.

A dinner preceded the meeting at which some 60 members attended.

Columbus Section

Ferdinand L. Jesse, *Secretary*

With 175 members and guests attending the January 12 meeting, sponsored by the Ohio State University Student Branch, Major Richard L. Johnson, Chief, Fighter Operation Section, Flight Test Division, Air Materiel Command, spoke on "Experimental Flight Testing of Air Force Aircraft."

The talk was accompanied by moving pictures of the initial flights of the F-86 jet fighter and its record speed runs.

Preceding Major Johnson's talk, films were shown of the ditching of a B-17, tests on wheels and tires, ejection seat in operation, and the Captivair trainer.

Dayton Section

William A. Barden, *Secretary*

A joint meeting was held at which the Section members were guests of the Detroit S.A.E. Section on January 18. Andrew Kalitinsky, Chief Power Plant Engineer, NEPA Project, Oak Ridge, spoke on "Atomic Power and Aircraft Propulsion."

▸ **Close Harmony**—Atomic energy as a source of power for aircraft promises to achieve a result unobtainable with standard fuels—airplanes combining extremely high speed with almost unlimited range—according to Mr. Kalitinsky. Such an application of nuclear power may eventually make possible a supersonic bomber capable of flying around the world without pausing to refuel, he said.

He added that the "practical development of atomic energy as a source of power calls for active cooperation of both scientists and engineers, in research institutions and in-

Silicone News

DC SILICONES

Increased Volume Cuts Cost of Silastic*

Design engineers weigh the properties and service life of a material against its price per pound. Sometimes there is only one material that will serve the purpose and price becomes relatively unimportant. That has been true of Silastic, the Dow Corning Silicone Rubber. But this initial market for Silastic has now become large enough to permit more efficient production and the opening of new markets through a price reduction of 20 to 45 cents a pound.

In the aircraft industry Silastic found a good initial market because it is the only resilient material that withstands hot oil and both high and low temperatures. Typical uses are: sealing thermal anti-icing systems; gasketing engine rocker boxes; and flexible heating ducts.

Silastic tubing reinforced with glass cloth is used to seal heating and ventilating ducts operating at 350-400° F. in Consolidated's Vultee Convair-Liner; in jet type planes at temperatures of 350-450° F. and under pressures up to 150 p.s.i.

In the automotive industry gaskets are one of many applications for Silastic now under test.

PHOTO COURTESY CONTINENTAL MOTORS CORPORATION

Silastic gaskets in the push rod and tube assembly of Continental's air cooled truck and bus engines withstand hot oil and temperatures ranging from —90° to 500° F.

Only Silastic is serviceable at temperatures in the range of —70° to —150° F. and upward of 500° F. It also has exceptional resistance to weathering and to many chemicals, excellent dielectric properties and water repellency. For more information phone our nearest branch office or write for pamphlet No. F5-S-2.

*TRADEMARK REG. U.S. PAT. OFF.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Atlanta • Chicago • Cleveland • Dallas Los Angeles • New York

In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

dustry, if an early and successful application of this power is to be made."

Kalitinsky pointed out that there are definite limitations on the possible performance of chemically fueled aircraft, since the required gross weight of the plane increases with both range and speed. For a given speed, he said, the gross weight increases rapidly with the range as the amount of fuel required increases, until the curve becomes practically vertical.

Must Find New Fuel—Because of this limitation on the speed/range performance of chemically fueled planes (this includes jets), we must find a new fuel, the speaker declared. Atomic power appears to be an extremely attractive solution if we are to extend range beyond the radius of current or projected aircraft using standard fuels. Our present supersonic planes, he said, run out of fuel in a matter of a few minutes. With atomic power, they could keep going, because the fuel supply would remain nearly constant.

Detroit Section

Henry H. Kerr, *Secretary*

"Operation and Use of Electric Analog Computer" was the subject of a talk by Dr. M. H. Nichols, Associate Professor of Aeronautical Engineering, University of Michigan. Robert Dale, Chairman, presided at the meeting attended by 33 members.

▶ **Demonstrates Equipment**—Dr. Nichols showed how a simple type of electronic analog computer operates in a demonstration with the actual equipment illustrating its use to solve typical problems such as dynamics of a mass spring combination with viscous and dry friction, normal modes of vibration of a uniform beam, etc.

The method of solution of more complex problems, such as nonuniform beams and aircraft and autopilot combinations, was indicated and results presented.

Informal discussion during and after the talk brought forth the fundamental simplicity, accuracy, and broad scope of the problems that can be solved by the analog computer.

Dr. Nichols is a graduate of Massachusetts Institute of Technology (Ph.D., Physics). During the war he developed flight-test equipment, including radio telemetry for military aircraft and rockets. Since the war he has engaged in development of methods for meteorological measurements through the use of rockets and studied analog computers as applied to aeronautical problems.

New York Section

R. Dixon Speas, *Secretary-Treasurer*

Under the Chairmanship of Charles Froesch, the Section heard A. E. Blomquist, Air Transport Consultant, January 18, on the subject of "Air Traffic Control, Its Problems and Possible Solutions."

▶ **Proposes Solution**—Mr. Blomquist's paper covered a proposed solution to the airway traffic problem of Metropolitan New York, centering about New York International (Idlewild) Airport, La Guardia, Newark, and Teterboro airports as the major transport terminals.

Prepared discussions on the paper were made by John F. Gill, Chief Pilot, Eastern Region, Eastern Air Lines; Robert W. Ayer, Assistant Director of Flight Engineering, American Airlines; John Groves, Air Transport Association of America; and George E. Bevins, Manager, Aviation Department, George M. Brewster & Son.

▶ **Reveal Booster Rocket**—On February 8 at a press conference held at the I.A.S. Building in New York, Dr. Ralph E. Gibson, Director, Applied Physics Laboratory, The Johns Hopkins University, who delivered a paper later in the evening on "Supersonic Guided Missiles," disclosed that the U.S. Navy has successfully flown the world's largest solid propellant rocket designed for use with long-range guided missiles.

A member of the scientific group that developed the proximity fuse, Dr. Gibson revealed that the new rocket "has a ground-level thrust considerably in excess of that developed by the German V-2 rocket." The V-2 exerted some 58,000 lbs. of thrust at launching and rapidly accelerated to 3,500 m.p.h., developing the equivalent of 600,000 hp.

The new rocket will be used, said Dr. Gibson, to launch supersonic missiles powered by ram-jet engines that must be boosted to speeds close to those of sound before operating efficiently.

▶ **U.S. Leads World**—Supporting Dr. Gibson's disclosures, Rear Adm. Frederick I. Entwhistle, Director of the Research Division, Navy Bureau of Ordnance, which is responsible for guided-missile developments, said that work at The Johns Hopkins University had placed the U.S. in world leadership in the ram-jet field.

Regarding a possible defense against long-range guided missiles launched against the U.S., Dr. Gibson said that American scientists "may have the answer in the next couple of years."

He added they already have come a long way toward equalizing things.

The lecture, delivered at the Engineering Societies Auditorium, was in joint session with the American Rocket Society. More than 500 members attended the meeting, with New York Section Chairman Charles Froesch presiding.

Philadelphia Section

J. Albert Roy, *Secretary*

A panel discussion on "Practical Aspects of Engineering" was held during the January 19 meeting at which Alfred Wolf, Vice-Chairman, presided. The talks centered principally about the many ills in design from a maintenance standpoint.

There were three speakers: Bruce H. Pauly, Westinghouse Electric Corporation; Ernest Buehl, Owner-Operator, Flying Dutchman Airfield, Somerton, Pa., and Joel Jacobson, Director, Technical Engineering Department, The Glenn L. Martin Company.

▸ **Service Conditions**—The first speaker, Mr. Pauly, a former combat maintenance officer and an engineer, told of nearly impossible service conditions. He stressed as the most important factors: durability, accessibility, trouble shooting, ease of maintenance, and repairs.

The fixed-base operator, Mr. Buehl, told of things done to a private plane which almost drive him out of business, such as nonaccessibility of batteries and wide variations in screw threads, preventing interchangeability.

The last speaker, Mr. Jacobson, pointed out that the complexity of the modern plane had greatly increased the time necessary for design. This calls for many men, he said, many with little experience. Other factors along with inexperience, such as excessive care and overingenuity, were cited by the speaker as sources of trouble.

▸ **Rogers Fund**—The Advisory Committee met later to discuss an offer of Mrs. John Rogers, of the late John Rogers' library. It was decided to submit the list of publications to The Paul Kollsman Library for recommendations for distribution, with suitable recognition of Mr. Rogers. It was also decided to give Section members a chance to participate in a "John Rogers Fund," the proceeds of which would be used to procure and donate aeronautical technical books to a Philadelphia University, probably either Temple, where Rogers taught, or Drexel, where he attended school.

San Francisco Section

John A. Stern, *Secretary*

At the January 6 meeting, held at Lucca's Restaurant, with Chairman Elliott Reid presiding, Robert H. Hoover, Project Engineer for the XC-99, gave a stimulating talk for 49 members and guests.

▸ **From Drawing to Flight Test**—The speaker, whose subject was the development of the Convair XC-99, stressed the time required to develop an airplane from the drawing board to flight test.

To obtain an airplane such as the XC-99 with a range of 10,000 miles with 10,000-lb. load of cargo required the utilization of many unique and improved design features, Hoover said. Since long range with large loads were prime design considerations, a low-drag, high-performance laminar-flow airfoil of NACA 63 series was used, since it would provide high performance while at the same time not be so theoretically perfect as to demand extremely high standard to finish.

▸ **50 Per Cent Useful Load**—That the efforts of the engineers met with success is indicated by the fact that the useful load of the XC-99 represents approximately 50.1 per cent of the design weight of 265,000 lbs., Hoover declared.

Los Angeles Section

E. P. Hartman, *Secretary*

On January 21, 125 lucky men, picked by lottery from the 1,000-strong Los Angeles Section, were guests of the Navy on a day-long sea trip and in the evening were entertained at dinner by the Navy at the Allen Center Officers Club on the Terminal Island Base.

▸ **Cruise of the Antietam**—Hosts of the I.A.S. were Rear Adm. Paul Hendren, Commandant of the Long Beach Naval Base; Rear Adm. Dixwell Ketchem, Commander of Carrier Division 5; and Capt. J. V. Peterson and Comdr. E. O. Rigsbee, Jr., Commanding Officer and Executive Officer, respectively, of the "U.S.S. Antietam," an aircraft carrier.

The ship got under way shortly after 7 a.m., and, while the I.A.S. guests were enjoying a hearty breakfast in the Ward Room, she headed seaward in the general direction of Catalina Island.

▸ **Calm Sea**—The sea was calm throughout the cruise, the sky generally overcast, with storm clouds hovering on the horizon, but there was no rain—or snow.

The schedule began with a tour of the ship, of which only the radar room, the Captain's bridge, and topmost radar antenna were off limits to the guests. During the tour, launching and landing operations on the carrier deck were carried out with a a group of 16 F4U fighters from the nearby El Toro Marine Base, none of the ship's regular aircraft being on board at the time. Some of the planes were landed at the rate of one every 32 sec.

▸ **Gunnery Practice**—In the afternoon, gunnery practice was held with 20-mm. and 40-mm. guns. The target was a tiny radio-controlled drone airplane catapulted from a launch that followed the carrier. The grace and facility with which the drone could be maneuvered by the "pilot" in the launch was impressive.

The first drone was hit in short order, and any valuable parts of its shattered remains were recovered by parachute.

▸ **Foolhardy Indifference**—A second drone catapulted from the launch fared better. It flew safely through a snowstorm of tracer shells, showing its complete and foolhardy indifference by doing loops and barrel rolls within easy range of the guns.

It was still kicking up its heels in the cold winter sky when the frostbitten guests retired to the Ward Room for coffee and doughnuts.

The dinner, at the Allen Center Officers Club, reportedly the most handsome Officers Club in the country, was outstanding in the food served and the personal contribution of champagne to the festivities made by Admiral Hendren. What is more, he regaled the guests with a number of salty stories about ships and men and other things.

▸ **Admiral Serious**—Not all the admiral's talk was on the side of light entertainment—he was serious when he spoke of the need of supporting naval aviation. Elimination of naval aviation now, as some groups are inclined to advocate, would represent, Admiral Hendren asserted, the throwing away of decades of accumulated know-how, as well as destruction of an essential arm of the country's defense organization.

The U.S. Navy, he declared, could, within 60 days, put enough of its "stored" carriers into action to form four powerful task forces, sufficient to bring 1,000 planes to bear on almost any point in the world over which this country might want to obtain or maintain control. Such a national defense resource, Admiral Hendren stated, must not be discarded.

1 Trim Trol

Tab Actuator with Filter and Transmitter designed for installation in the leading edge where it can serve as mass balance. ZERO BACKLASH at output shaft permits operating tab with simple link to obtain varying mechanical advantage increasing with load.

2 Lineator

Linear Actuator with Filter and Transmitter operating loads to 1500 pounds with low basic weight. Static capacity over 5000 pounds. Performance characteristics variable to suit application.

3 ROTORAC

Right Angle type with Filter and Transmitter for driving screw jacks or flex shafts. Typical rating 15 inch pounds at 60 R.P.M. on 3 minutes out of 15 duty cycle. Higher ratings depending upon application.

4 Servo Systems

Incorporating our electromechanical equipment to obtain synchronizing or positioning effects from any type of signal for automatic operation or for manual control eliminating indicators.

5 ANG Gear

Standardized bevel gear drive for use in either manual or power operated systems. Anti-friction bearings and hardened gears. 500 inch pounds ultimate. Pressurized seal on mounting end optional.

AIRBORNE
ACCESSORIES CORPORATION
25 MONTGOMERY STREET • HILLSIDE 5, NEW JERSEY
Sales Representatives
JAMES L. ADAMS & CO. • LOS ANGELES 6, CAL.
W. N. WRIGHT • DALLAS, TEXAS

Student Branches

Aeronautical University

Election of new officers took place at the January 20 meeting as follows: Chairman, L. L. Ferryman; Vice-Chairman, M. M. Allison; Secretary, K. W. Lesher; Treasurer, H. T. Walker; Sergeant-at-Arms, E. H. Lampi; Honorary Chairman, C. G. Skeker; Honorary Vice-Chairman, R. P. Fuqua.

The new Chairman was unopposed in the election.

University of Alabama

The Branch held its first meeting of the winter quarter on January 25, Thomas Meledy, Chairman, presiding.

Featured speaker of the evening was Edward Linsley, aeronautical engineer undergraduate, who spoke on "The Behavior of Gyroscopes and Their Applications to Aircraft Instruments."

Mr. Linsley outlined the principles of gyroscope operation and construction. He covered in detail the principle and construction of the gyro compass, gyro horizon, turn-and-bank indicator, and the gyro-automatic pilot. At the close of his talk, possible future applications of the gyroscopic principles were discussed.

Cal-Aero Technical Institute

The December 7 meeting featured the presentation of the I.A.S. Scholastic Award to Alf S. Lied by Hugh Nicholson, Director of Training at Cal-Aero Tech.

The principal speaker at the meeting, Anthony LeVier, Chief Engineering Test Pilot, Lockheed Aircraft Corporation, described the flight testing of the P-38, F-80, and the Constellation, vividly revealing the many problems encountered in flight testing.

Color films showing the flight testing of the Connie and F-80 were shown.

Carnegie Institute of Technology

A talk on the "Modification of the C.I.T. Wind Tunnel Suspension System" was given by Robert F. Chesarek, Mechanical Engineering Instructor, C.I.T., at the January 11 meeting. Chairman George E. Bayuzick, Jr., presided with 21 members present.

Mr. Chesarek's talk consisted of a detailed explanation of the installation of the new platform balance, model suspension system and the advantages of the new system over the old wire model suspension system in the wind tunnel at Carnegie Institute of Technology. The speaker conducted the members on a tour through the school's wind tunnel at the conclusion of his talk.

The Branch consists of 30 active members.

Catholic University of America

At the January 12 meeting four films were shown to the 45 members present. These included: *Carrier Deck Crash Hazards, Pilotless Aircraft Research, Compressibility Effects on Naval Aircraft,* and *Photography in Naval Intelligence* ("*C*" *and* "*D*"). Marcian A. Herman, Chairman, presided.

University of Colorado

A report on the membership and financial status of the Branch was made by Maurice Brull, Treasurer, at the January 13 meeting. There were 73 paid members as of that date.

Mr. Brull then introduced the speaker for the evening, A. M. Griffin, C.A.A.—Denver, who spoke on "C.A.A. Procedures."

Mr. Griffin described the organization and functions of the C.A.A. He contrasted the duties of the C.A.A. and Civil Aeronautics Board, emphasizing how the two organizations work together.

Illinois Institute of Technology

Final meeting of the semester took place on January 11 at which a summary of activities for the coming Illinois Tech Open House was presented. Vice-Chairman Paul Margolis presided at the meeting with 17 members present.

Two films, *The History of Aviation* and *The Bomber*, concluded the meeting.

University of Illinois

The following officers were elected at the January 12 meeting with 70 members present: Chairman, Edgar Bourke; Vice-Chairman, William Barthel; Secretary-Treasurer, Robert Kelly; and Engineering Council, Richard Meyers.

Massachusetts Institute of Technology

Otto C. Koppen, Professor of Aeronautical Engineering, M.I.T., presented a lecture January 5 on "Aero-

nautical Design," the sixth and final lecture on the analysis of the Course of Aeronautical Engineering at M.I.T. Professor Koppen presented the advantages afforded by the field of aeronautical design and summarized some of the courses presented at M.I.T. for the study of design.

Chairman Lewis H. Roosa presided with 37 members present.

University of Minnesota

At the January 18 meeting, a talk on "Difficulties Encountered in Test Piloting Jets" was presented by Colonel Fleming and Colonel Horner, U.S.A.F., Wright Field. Chairman David Benepe presided, with 70 members present.

Oregon State College

The meeting of January 19 featured a talk, "Job Training," by Stanley H. Lowy, Instructor in Aeronautical Engineering, Oregon State, and a film, *Flying the Weather Map*, a movie issued by the Department of Commerce Weather Bureau in Washington, D.C.

The film presented the terminology and colors used on weather maps, and typical flying conditions were discussed for various types of air masses. The film stressed the importance of the pilot knowing the weather map in order to know at which altitude it is best to fly on long flights.

Mr. Lowy in his talk said he had found, as a result of letters to aircraft companies in 1947, that job training for inexperienced engineers existed in the following categories: pure mathematics and science, testing and research, and drafting.

In the first group the engineer usually works on basic calculations in aerodynamics and remains there for 1 or 2 years. In the second group, a more experienced engineer has charge of several new ones. If a new engineer shows sufficient aptitude, he may in time be placed in charge. The third category is more for the engineer to gain knowledge of the company's policy and methods.

Most engineers, said Mr. Lowy, get into development; few get into pure science. Most companies hire more mechanical engineers than aeronautical, according to his finding. Some companies have refresher courses and sections for advanced degrees if the designer wishes to get an advanced degree, he said.

The Pennsylvania State College

Two films were shown at the January 12 meeting, Chairman Donald L. Liebel presiding. There were 70 members present. The films were *Airplanes* and *Air Power Is Peace Power*.

Purdue University

Nominations for new officers were made at the January 4 meeting at which 45 members were present. Chairman Ken Jordan presided. Present membership totals 147 paid members. A film, *Flight Log*, was shown.

Stanford University

At the January 11 meeting, Chairman Wendell P. Garton presiding, a talk was given by Ralph F. Huntsberger, Research Engineer, Ames Laboratory, N.A.C.A., Moffet Field, on "Compressibility Effects on World War II Aircraft."

He described in detail the solution of compressibility problems in the P-36, B-29, and P-47. He also described problems that are confronting the Ames Laboratory research staff.

Texas A. & M. College

On January 18, the business session of the meeting was presided over by Chairman Curtis L. Turner, after which the meeting was turned over to Prof. Robert M. Pinkerton, who led a round-table discussion of the fields of employment in the aircraft industry.

Tri-State College

At the first meeting of the winter term January 12, Chairman Edward C. Klein appointed four committees as follows: Entertainment Committee—R. W. Gehring, R. G. Wellbaum, W. H. Shaw; Advertising—F. C. Townes, N. F. Lang, R. D. Wolcott; Ways and Means—W. P. Doyle, R. A. Kintz, E. F. Henz; and Seal Committee—L. J. Chestnut.

A talk on "Landing and Navigational Instruments" by Prof. Quintin J. Hawthorne concluded the meeting.

At the special meeting held January 19, a film, *Target Invisible*, was shown, after which a business session took place. Progress was reported being made on the V-tail and Channel-Wing projects.

Third meeting of the winter term was held February 2 at which plans were discussed concerning a raffle to take place in the near future. A Branch seal was ordered to be awarded each term to members meeting the requirements of the award.

University of Texas

Hugh Gillham, Chairman, called the January 12 meeting to order for nominations and election of officers for the spring term. Elected were Calvin Bill Hargis, Chairman, and Betty Jeanne Reynolds, Secretary.

The meeting then was turned over to Prof. Warren Arthur Meyer, Honorary Chairman, who introduced the speakers of the evening.

Subject of the talks was "The C.A.A. and Its Connection with the Aircraft Industry." First speaker was C. A. Biesmeier, who introduced the topic and briefly covered the history of the Civil Aeronautics Authority and the C.A.A. today. He next discussed the engineering aspects, emphasizing the approval of air frames.

R. R. Shute spoke next, stressing the procedure for obtaining approved type certificates for engines and propellers. John P. Jones discussed the flight testing of new aircraft.

Virginia Polytechnic Institute

The January 25 meeting was called to order by Chairman H. C. McClanahan for the purpose of electing new officers. New Chairman is C. B. Wood; Vice-Chairman, R. B. Brown; Treasurer, L. H. Weatherly; and Secretary, H. A. Wente.

Chairman Cleo Boothe Wood called the February 1 meeting to order and appointed members to various committees as follows: Program Committee, S. M. Gay, E. A. Wood, D. B. Cross; Spring Picnic Committee, R. B. Brown, F. P. Griffith, J. E. Montalbano; Engineering Council Representatives, C. I. Tynan, D. M. Prangay; Campus Poster Committee, C. P. Brewer, H. D. Davidson; Rad Tech Poster Committee, J. L. Cobbs and G. C. Frazer.

A film, *The Price of Rendova*, was shown after the meeting.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Dennis, Paul Arthur, B.S. in Physics, Chief, Engineering Lab., Douglas Aircraft Co., Inc. (El Segundo).

Gerdan, Dimitrius, B.S. in M.E., Chief Engine Engineer, Allison Div., General Motors Corp.

(*Continued on page 101*)

Personal Planes –
Then –
Now –
?

Editorial

Of Signs and Portents

Back in 1943, in an effort to forecast the postwar possibilities for personal aircraft (*Wings After War*, Duell, Sloan and Pearce, N.Y.) the opinion was offered that "nothing particularly new has turned up . . . that will effect any revolutionary change in the design of small, nonmilitary aircraft in the immediate postwar period . . . they will operate on the same basic principles as their prewar prototypes and will probably cost about as much initially and to maintain." Further, it was observed that it would be "most misleading to try to draw parallels between the private automobile and the private airplane (industry)." The two cases are not at all comparable. "The automobile developed a huge annual market because it became one of the most useful machines ever invented by man. It stands patiently at our elbows, ready at a moment's notice to perform a host of small but necessary duties . . . We cannot get along without it. So, until some form of aircraft comes along that can do *everything* that the automobile can do, *and also fly*, the market for privately owned aircraft will be limited to those income groups that can afford *both*."

Five years later (during the 1948 "Meeting on Wings," of which he served ably as keynoter) Grover Loening reiterated substantially the same idea. He warned that unless some form of aircraft could be developed that would cover a controlled flight speed range of "zero to 200 m.p.h." and do it simply and economically, no real market for personal planes could be anticipated. He predicted, however, that the advent of such a vehicle might easily lead to a demand for half a million units a year!

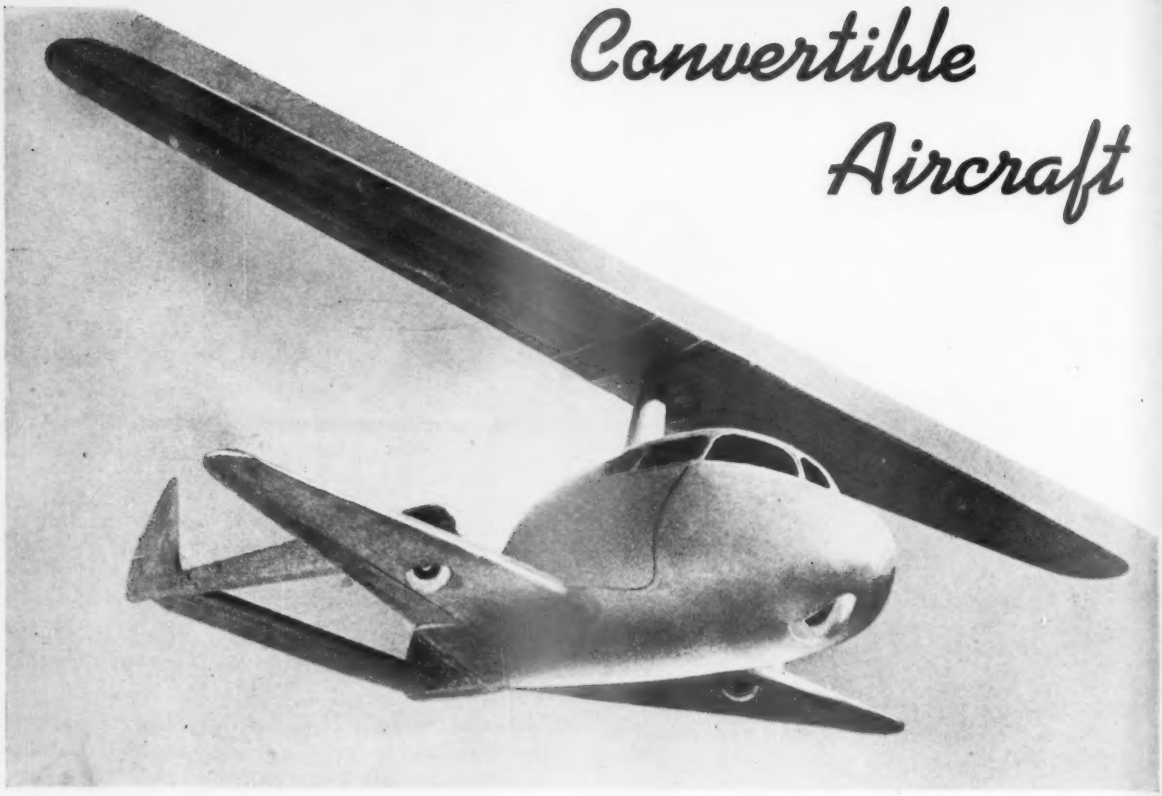
Here was a real challenge. It called for courage and some revolutionary thinking, but it offered some hope of breaking the ancient deadlock and of opening up a real market for personal aircraft. Furthermore, it came from the country's oldest aeronautical engineer, a man whose personal flying experience covers over 30 years.

A full year has gone by since Mr. Loening made his provocative remarks. During that period the sales record of personal plane producers has been showing some alarming symptoms. With the end of G. I. Bill training in sight and with a general tightening of money throughout the country, sales have slacked off noticeably. Quite obviously, there *is* a limit to the market potential of the conventional private airplane.

With all these warnings, signs, and portents in plain view, we are looking forward with interest to the Sixth Annual Personal Aircraft Meeting of the Institute, slated for Wichita on the 29th and 30th of April. (The program will be found elsewhere in this issue.) Now, if ever, is the time for some really original thinking to be on display. To us it seems that the real crisis is now at hand. If we as engineers are content to rehash and refurbish the old concepts of personal airplane design, then the future of personal flying is dim indeed. Conventional aircraft design has been tried and found wanting. Only if we "get off the dime" and do some real "out in the blue" thinking will we ever lay the foundation for the 500,000 plane years that Grover Loening has been talking about. We hope that that thought will be held foremost in the minds of all who assemble in Wichita this month.

S. P. J.

Convertible Aircraft



A Statement and Discussion of the Problem

by
R. S. Barnaby
S. M. Berkowitz
W. H. Colcord*

DURING RECENT YEARS, aircraft with conventional fixed wings and aircraft with rotating wings have enjoyed rapid development as separate types. The fixed-wing craft have offered a combination of high speed with high load-carrying capacity, while the rotating wing craft—autogiros and helicopters—have provided slow flight with adequate control, ability to take off and land in restricted areas, and, in the case of the helicopter, the ability to rise and descend vertically and to hover.

It is believed that there is available now enough knowledge of the potentialities and limitations of each of these types of aircraft to warrant a systematic investigation of combinations of fixed and rotating wings to determine whether the major advantages of each type may be incorporated into one aircraft, without having to accept at the same time too many of their shortcomings and difficulties.

Let us first review briefly the characteristics of the two types of aircraft. In the fixed-wing airplane, we have, on the credit side of the book, high speed, load-carrying ability, high rate of climb, ability to fly at high altitude, simplicity (relative, of course) in structure and control, and fuel economy.

On the debit side are high speed of take-off and contact, undue length of take-off and landing run, flat angle of descent, inability to fly slowly or to hover, and a reduction of control efficiency at its lowest speeds.

In the helicopter we have, on the one hand, the ability, like the automobile, to travel at any speed from 0 m.p.h. to its maximum rate. It has no critical stalling speed in the usual sense and can therefore slow down and stop at will, without impairment or loss of control. The helicopter in flight can stop from a forward cruising speed in a short distance.

The helicopter has a steep angle of climb and descent and, with this, the ability to rise from and alight in restricted and unprepared areas. Even in the event of power failure, given adequate altitude, the helicopter can autorotate to a safe landing on terrain impossible for the conventional airplane.

On the other hand, we find in the helicopter some disadvantages and difficulties. Its top speed is low, its carrying capacity is low, and its stability is marginal. While its angle of climb is good, the rate of climb is not. Its ceiling is limited, its structure, drive, and control

Presented at the Aircraft Design Session, the Seventeenth Annual Meeting, I.A.S., New York, January 24–27, 1949.

* Franklin Institute Laboratories for Research and Development.

are complex, and, lastly, its fuel consumption is relatively high.

In analyzing the convertible aircraft as a practical flying machine, all the necessary characteristics must be considered and evaluated.

(1) *Personal Comfort.*—The pilot and passengers should be seated normally and comfortably and not be subjected to unusual positions, angles, or accelerations, certainly no more so than in conventional airplanes.

(2) *Take-Off, Landing, Hovering, and Vertical Flight.*—The aircraft should be capable of vertical ascent to reasonable altitude for safe conversion. It should be able to hover and to take off and land without horizontal speed at reasonably high altitude and temperature.

(3) *Horizontal Flight.*—It must be capable of fixed-wing horizontal flight at speeds comparable to those of conventional airplanes of its size and power.

(4) *Conversion.*—Conversion from direct-lift to fixed-wing flight and, vice versa, must be accomplished with complete continuity of lift, stability, and control and without unusual velocities, attitudes of flight, or forces.

(5) *Maneuverability and Control.*—It must be reasonably stable and controllable in all conditions of flight, without undue complication of controls for the pilot.

(6) *It Must Have Mechanical Practicability.*

As a first step in analyzing the problem, two general classes have been established, and an attempt has been made to classify and group under these classifications various means of accomplishing the transition and to illustrate and discuss examples of each.

The first class embraces those craft wherein the rotor axes remain substantially vertical, as in the case of the conventional helicopter.

The second general class embraces those in which the axis or the rotor or rotors swings from vertical to horizontal in transition to fixed-wing flight.

In the first class, all the flight components of a fixed-wing aircraft are present and in normal position during all phases of flight. Low speed, vertical flight, and hovering are accomplished by direct lift, as in the conventional helicopter, and the rotor is stopped or started in the course of the conversion. (Fig. 1.)

This class may be divided further into three groups: one in which the rotor blades when stationary are swallowed into the hub or otherwise housed within the structure; one in which the blades are stopped in a minimum drag position; and, finally, one in which the blades, when stationary, become fixed wing surfaces.

In this whole class, of course, separate propulsion means are required for fixed-wing flight, with the possible exception of one that will be mentioned later.

While each of these types involve the addition of power-driven rotating and controllable lifting surfaces to all the components of the existing fixed-wing airplane and contain features that cause some of these components to be redundant in certain conditions of flight the fact that there is a propeller and fixed wing available to fly on makes this class a promising one for initial investigation.

Each, of course, presents its own individual problems, but the problem of starting and stopping the rotor while in flight is common to all, except perhaps to the one in group 1 where the blade is retracted into the hub. Here, the method of retraction may be a complementary difficulty, the problem of retracting the blades against the centrifugal force being substituted for the problem of stopping it first. Another problem common to this class is the matter of rotor propulsion. If the rotor is driven by a power plant in the body, antitorque devices must be provided. If the propulsion means is in the rotor itself, either in the form of tip jets or other power plant wholly within the rotor, body heading in helicopter flight will still have to be controlled for practical operation.

Assuming that the problems of stopping and starting the rotors may be accomplished in a practical manner and that the mechanical problems of drive and control have been solved, what are the aerodynamic problems of conversion in this class?

The craft lifts off the ground vertically as a helicopter and at conversion altitude starts to advance, still as a helicopter. As its forward speed increases, the fixed wings assume a greater and greater portion of the lift, and the propeller assumes a greater share of the forward thrust, until at some speed above the stalling speed of the fixed wing the airplane part of the craft becomes self-supporting. It is assumed that, as this is taking place, the rotor is being slowed down and otherwise discarded and stowed at a rate such that, between the rotor and the fixed wings, the craft will receive full support for horizontal flight and adequate control throughout the transition. In the third group, as represented by Mr. Herrick's Convertoplane, where the rotor becomes fixed wing, an intermediate phase of autorotation with joint distribution of load between it and the permanent fixed wing is interjected which should facilitate transition. Nevertheless, analytical studies and comprehensive wind-tunnel tests should be conducted to determine just what the details of this transition involve.

Mention has been made of retractible blades, and at this point it might be in order to mention the experi-

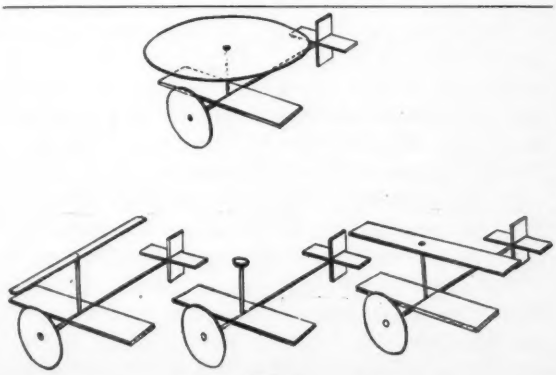


FIG. 1.

FIG. 2.

FIG. 3.

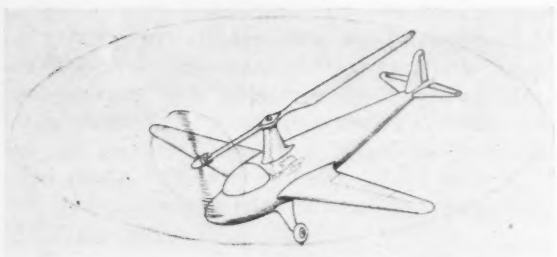


FIG. 4.

ments of Vittorio Isacco in England. (Fig. 2 shows a photograph of one of his units from a recent issue of the *London Illustrated News*. This unit, which has an expanded diameter of 30 ft. and a retracted diameter of 3 ft., has been undergoing ground tests mounted on a track. These tests have been in autorotation only.)

The idea of stopping the rotor and lowering it axially into the wing structure has been suggested by various experimenters.

Stopping a single-bladed rotor in its aft-trailing low-drag position has been proposed by E. Burke Wilford, of Philadelphia. One of his suggestions is a jet-driven rotor on a conventional-looking airplane.

(Fig. 3.) In another intriguing Wilford-deMonge suggestion, a buried engine in the fuselage drives a swivel-mounted propeller on the counterbalance end of a single-blade rotor. (Fig. 4.) In this arrangement the propeller, when swiveled so that its axis is tangential to the rotor disc, drives the rotor for helicopter flight. In transition the rotor is stopped and locked with the rotor blade aft and the propeller forward, swiveled so that its axis is parallel to the axis of the airplane. The propeller then provides direct thrust for airplane flight. The sketches do not indicate how he proposes to handle the antitorque problem in vertical flight though provisions would have to be made.

Smooth transition in this case appears impossible. To go from direct-lift flight to fixed-wing flight it would seem necessary first to get forward speed as a helicopter sufficient to attain wing support, then go into a glide while the propeller was idled, the rotor stopped and locked, and the propeller swiveled to face forward. Power could then be applied and normal airplane flight attained. This is the one type in this class mentioned earlier as needing only one means of propulsion. It appears possible that a jet type might also be developed along these lines. Mr. Loening, we understand, has so suggested.

Other types falling in this group include those in which the rotor, after it has been stopped, is lowered so that it houses in a recess in the top of the fuselage or wing. Antoine Gazda, of Providence, R.I., has proposed such an arrangement. His two-bladed rotor would lie fore and aft along the fuselage top when not in use. The raising and lowering of the rotor, of course, adds its share of complication to the general problem. In both these groups, of course, the rotor becomes dead weight when not in use.

The third group in this class comprises aircraft wherein the rotor blades, when stopped, act as conventional fixed-wing area. This type, pioneered by Gerald P. Herrick, of New York, often called "the father of the Convertoplane," has been demonstrated successfully insofar as the transition from fixed wing to autorotating wing is concerned in many actual full-scale flights as early as 1937.

Mr. Herrick's latest design proposes a low-wing, twin-boom-tail pusher airplane with a tip-jet-propelled rotor wing overhead, incorporating complete cyclic and collective pitch control. (See Fig. 5, photo on page 20.)

Mr. Herrick has developed an airfoil section symmetrical about a vertical centerline which shows acceptable aerodynamic characteristics. A symmetrical airfoil, of course, is necessary, since what is the trailing edge of one wing when acting as a rotor blade becomes the leading edge in fixed-wing operation. The Herrick convertoplane, as he calls it, has demonstrated that the transition from fixed-wing to autorotating wing presents no great problem in design or operation. In addition, he has designed an ingenious locking mechanism for the wing when at rest and anticipates no great

difficulty in stopping the rotation at will. We understand that Mr. Wilford's Gyroplane, the Navy XOZ-1, during flight tests in 1937, was able to reduce its rotor speed from a normal 220 r.p.m. to 90–100 r.p.m. merely by partial unloading of the rotor onto its 100-sq.ft. fixed wing.

It would appear possible with Mr. Herrick's arrangement to make smooth transitions without loss of altitude and with full control.

The authors believe this is of great importance, since they do not feel that a craft in which transition at some stage leaves the aircraft in a condition of inadequate lift or control or where conversion involves extreme or acrobatic maneuvers is a reasonable or practical flying machine.

In the second class, where the rotor axis changes from vertical to horizontal in conversion, we have several groups: first, (Fig. 6), those in which all the flight components of a fixed-wing aircraft are present and in normal attitude during all phases of flight, the transition from helicopter flight to airplane flight being accomplished by swinging the rotor axes from vertical to horizontal, thus converting the rotors to propellers; second, those in which the body, wings, and rotor axes maintain a fixed relation to each other, and the whole works swings through approximately 90° in the course of the transition.

Typical of the first group is a design proposed by Lawrence LePage, (Fig. 7) which resembles a conventional transport with wing-tip nacelles mounting rotors which pivot about a transverse axis to permit conversion.

A small experimental man-carrying aircraft of this general type is now under construction by another group. It is hoped that it will be ready for ground tests late this coming Spring. Some idea of its size may be obtained from the fact that the rotors are approximately 17 ft. in diameter, and their axes are 20 ft. apart. Performance calculations by the projectors of this aircraft indicate that transition will be a smooth operation, the fixed wings taking on load as the rotor axes are rotated from vertical to horizontal, so that horizontal flight may be maintained throughout the transition. When operating as a helicopter, all control is through the rotor system in accordance with normal helicopter practice. To attain forward motion and to increase speed, the effective rotor discs are inclined forward either by cyclic-pitch control or by tilting the axes mechanically. As the forward speed increases, the fixed wing starts taking an increasing share of the load. This, in turn, permits a larger percentage of the rotor force to be used for forward propulsion. The actual turning of the rotor axes from vertical to horizontal and vice versa will be by a mechanical turning mechanism. By this procedure the wing is loaded until it is the only lifting surface, the rotors become wholly propulsive, and it is hoped a smooth transition will be accomplished.

Louis deMonge, a French designer now in this country, has proposed a design that belongs in this

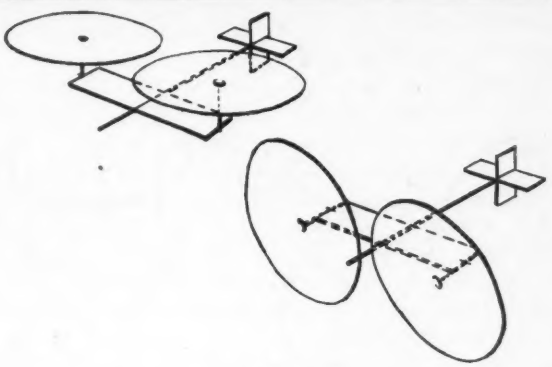
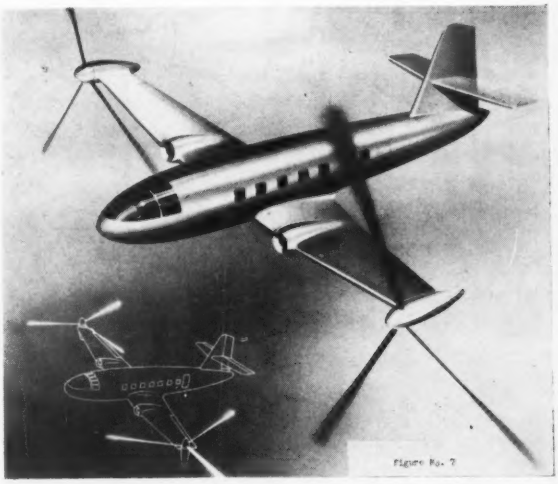
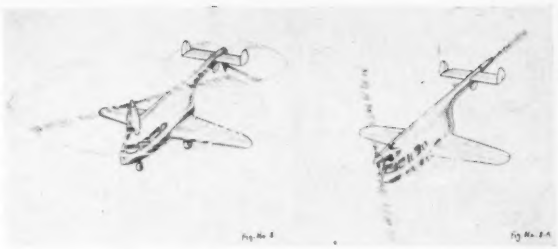


FIG. 6.





group. (Fig. 8.) In this craft there is one rotor forward and above the fuselage and the other is aft and below. The axes of these rotors swing from vertical to horizontal to provide a tractor and a pusher propeller. Transition in this case is the same as just described. (Fig. 8-A.)

Next, we have two groups in which the rotor axis and body swing together from vertical to horizontal. (Fig. 9.) In the first, again the elements of the airplane—wings, fuselage, tail, and all controls—are present, but the whole air frame stands on its tail during the helicopter or direct-lift portion of the flight. A patent dated 1935, issued to Dr. George Myers, of New York, as well as later patents to Lloyd Leonard, shows such an arrangement. In this configuration, transition is to

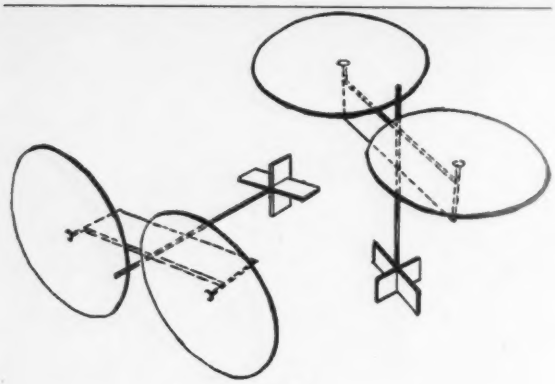


FIG. 9.

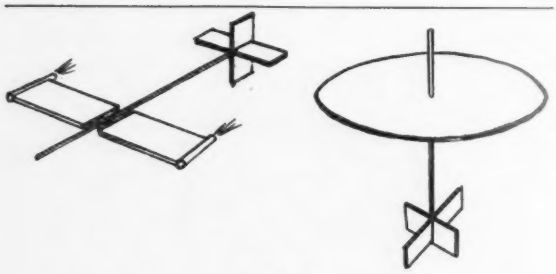


FIG. 9-A.

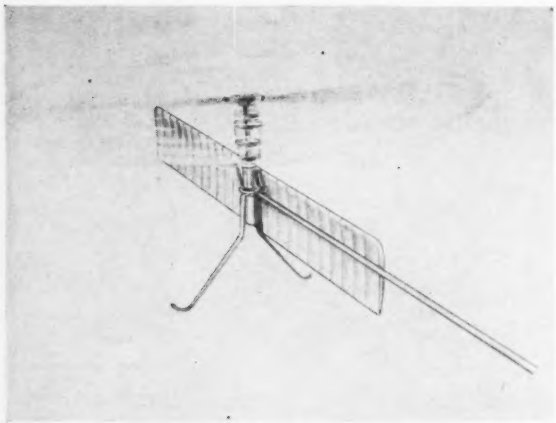


FIG. 10.

be accomplished by simply rolling the craft over from the vertical to a horizontal attitude.

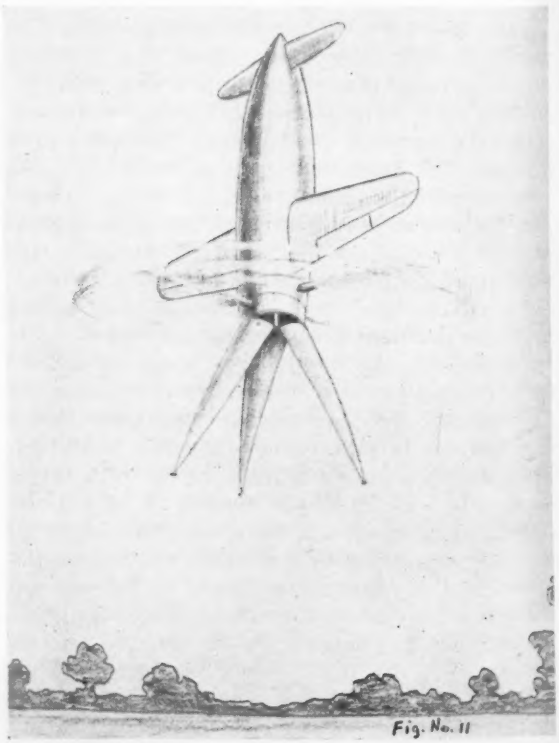
In the other group the body again is vertical for ascent and descent, but in the transition from vertical to horizontal flight the rotor blades become wings. (Fig. 9-A.)

Arthur Young, formerly of Bell Aircraft, has long been interested in the first of these groups and has built several successful flying models. (Fig. 10.) The model shown was powered with an electric motor attached to a rotating arm through which electric power lines for the motor, and rotor-blade cyclic, and collective pitch controls were lead.

The Vought-Zimmerman XFU-1, commonly called the Flying Pancake, belongs to this group. It is understood that Mr. Zimmerman is continuing along these lines with definite provision for vertical ascent and descent. The General Electric Company, under the direction of David Prince, did experimental work also falling into this group.

While this configuration probably is the simplest mechanically, the aerodynamics of stability and control through the transition phase will require considerable research. It appears that, as the craft rotates from the vertical to a horizontal position, the rotor may shed its lift faster than the wings will be able to take it on. It seems probable, for instance, that during the transition a point will be reached where the rotor has lost a large portion of the vertical component of its thrust while the wing is still at an angle above its stall, unless we can count on the rotor slipstream effect and the wing-lift induced thereby to make up the difference. The alternative will be for the craft to turn all the way over to a nose-down attitude and pick up fixed-wing flying speed in a dive or at least a steep power glide.

Fig. 11 shows a conception of one version of such a craft in the vertical ascent or descent attitude. Fig. 12 shows the same machine in horizontal flight. Frankly, however, it is our opinion that craft of this type—which have two separate attitudes of flight, one 90° from the other, and which may, in addition, have to undergo further extreme change in attitude and considerable loss of altitude as well during conversion—cannot be considered seriously, except perhaps for military purposes and for guided missiles.



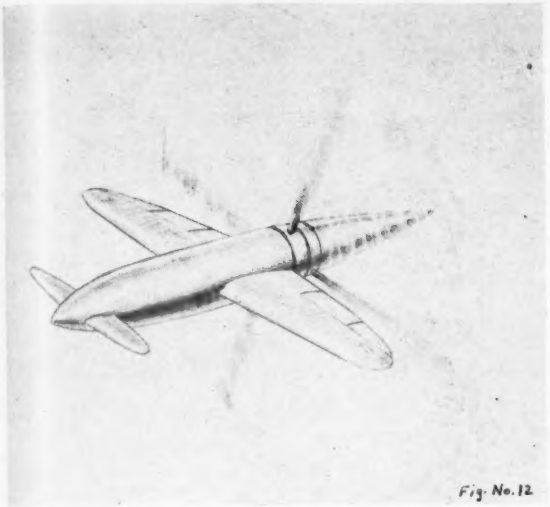


Fig. No. 12

The last variation we have considered is the one that takes off and lands vertically, and in transition its rotor becomes fixed wing. Fig. 13 shows such a craft in vertical flight, using tip-jet propulsion. In transition to horizontal fixed-wing flight the whole configuration swings from a vertical position to horizontal. At the same time the pitch of the rotor blades is increased and rotation speed is reduced. The blades become fixed wing, the same tip jets providing the thrust for airplane flight. Fig. 14 shows this model in horizontal flight.

It is apparent that the transition in this case presents many problems. It seems certain, for instance, that, at some stage of the operation when the rotor pitch has become high and its rotational speed low, the craft will have become, shall we say, vagrant (a vagrant, of course, being one without visible means of support!). Here again the craft will have to turn clear over and attain its fixed-wing flying speed in a power dive.

Reconversion to rotary-wing flight does not appear to present so much of a problem. The craft will just be zoomed up to a vertical stall and the necessary rotor adjustments made—a perfectly feasible maneuver, but one, nevertheless, that still falls into the acrobatic category and as such is highly undesirable. This reconversion method applies in some measure to all the groups described wherein the body changes from horizontal back to vertical in the process. In these cases there is no doubt that some positive control of rotation of the body must be provided. While it may not be too important which side one looks out when the fuselage is vertical, one would prefer to ride right side up in horizontal flight.

Consideration of emergency procedure in case of power failure is important. Such a failure during direct-lift flight would be no different from in the conventional helicopter. It would be necessary for the rotor pitch to be shifted to that required for autorotation and for the rotor to be permitted to "free wheel." Autogiro-type descent and landing would be made. The landing gear must be of a type that will permit translation during such a landing or be able to absorb the loads of vertical descent.

Power failure during fixed-wing flight presents additional problems. Transition to autorotative flight must be achieved before descent and landing as described above can be effected. The alternative, of course, would be a fixed-wing landing at the high speed required with resultant probable major damage to the complete aircraft.

In aircraft of the first class, this emergency conversion will require unhousing of the rotor and getting it in motion in autorotative setting. In aircraft of the second class it would involve getting the rotor axes shifted back to vertical and into autorotative action. Only careful analyses and experiments will show the possibility or practicability of such transitions and the minimum loss of altitude in which they may be effected.

There is no doubt that in the convertible aircraft, as in any multipurpose craft, redundancies must occur which have their effect on useful load and some phases of performance. In certain cases, there will be compensating weight reductions; for instance, a reduction in fixed-wing area, since fixed-wing flight will only be indulged in at high speed where less area is required than is needed for take-off or landing. Again, since direct-lift flight is only to be used during take-off and landing and other occasions, perhaps, of short duration,

(*Continued on page 29*)

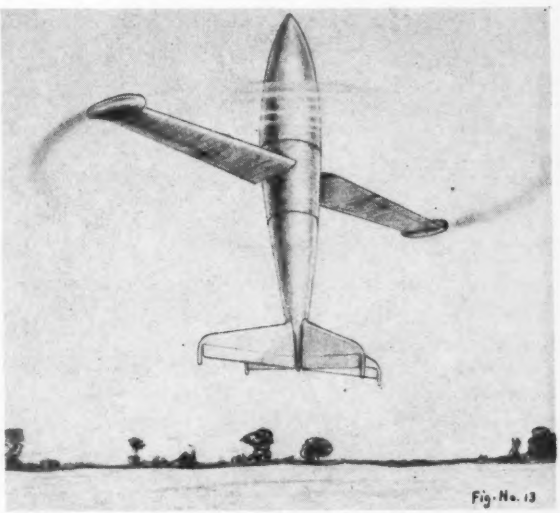


Fig. No. 13

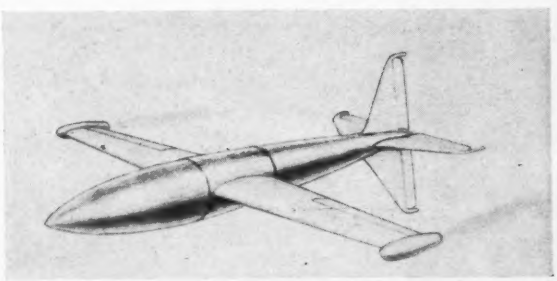


FIG. 14.

Synthetic Aircraft

By

Luis de Florez*

Excerpts from an Address Given at the I.A.S. Luncheon on January 26

"ONE OF THE GREATEST CONTRIBUTIONS of the Wright Brothers to aviation lies in the concept that aircraft do not fly but are flown—that the man-made flying machine must not only be provided with controls to maintain equilibrium and direct its path but that man himself must acquire the ability to fly it in order to achieve sustained flight.....

"The progress in aeronautics and science in general which has made possible the modern aircraft, with its almost incredible performance and complexity, has in no way lessened the task of the pilot in flight but, on the contrary, has created the need for even greater requirements in skill and knowledge. Each new increment of aircraft performance and size has brought with it greater possibilities and greater stakes, as well as greater lessons to be studied and learned. Indeed, flying has passed far beyond the category of physical skill to the realm of highly intellectual technical attainment....."

New Scale of Values

"In looking back through the years to the level of prices of aircraft of World War I vintage as compared with those of World War II, we get some idea of the change that has occurred. For instance, in 1918 the Curtiss Jennie cost the Government about $5,000, whereas the Stearman training biplane of World War II cost around $30,000. The Bristol and de Havilland fighters of World War I cost about $7,000 as compared to $250,000 for World War II P-38's. The heavy bombers of World War I, such as the Handley-Page, cost around $50,000 as compared with $600,000 for World War II B-29's. As for transport aircraft, the time-honored trimotor Ford, standard for many years, cost around $50,000 in the nineteen twenties compared with our Constellations and Stratocruisers, which cost over $1,000,000 each.

"Recent military contracts for aircraft indicate that the cost of large bombers is currently running over $4,000,000 each, with the cost of fighters from $300,000 to $600,000 each. Adding to this the knowledge that to design, build, and test a new type of major aircraft we must be prepared to spend 25 to 30 million dollars, we realize the magnitude of the stakes involved in the first test flights.

"The design of a new type of aircraft is, as we know, an incredibly complicated procedure involving months of calculations and wind-tunnel work to arrive at a compromise with form, weight, structure, and power which will constitute a better combination for service than that found in existing types.

"The performances and handling of the prototype is predicted by the designers from judgment based on model testing and analogy with other existing aircraft. The final judgment and proof of the resulting combination of an incredible amount of data lies with the test pilot who must accept the theoretical judgment of the designers and risk the whole development and himself on the first flight. There is perhaps no other branch of engineering and science in which we chronically risk as much effort and expenditure in the first throw of the dice....."

Electronic Computer to Preview Aircraft Performance

"The problem of evaluating and proving the combination of data brought together in the design of a prototype prior to actual test flight is a difficult one, but it can now be solved, insofar as flight characteristics are concerned, by the use of electronic computers of the type developed during the war for simulation of flight for training purposes. Such a computer can be made to portray the flight of the aircraft designed and furnish a preview of its performance. It can serve to examine the characteristics of stability and control

* President, de Florez Engineering Company.

for the benefit of the designer as well as the test pilot. Likewise, the task of familiarizing and training pilots and crews in the operation of the new type of aircraft can be met by the use of working mock-ups of the fuselage and cockpit of the projected aircraft made operative by such computers.

"The combination of computer and cockpit replica can be considered in effect a 'Synthetic Aircraft.' This combination has extraordinary possibilities in its application to the development of new aircraft and for the training of crews for both flight tests and for later regular operation, as was found to be the case during the war. To visualize such possibilities it would perhaps be helpful to review the Navy's wartime development of what became known as 'Synthetic Training,' the evolution of which brought about this type of equipment.

"Just prior to World War II it became apparent in naval training that the time-honored methods of teaching men to fly contact, tossing in a little instrument training to be amplified later, would be utterly inadequate to meet the requirements for the operation of the military airplanes then under construction. It was realized that the naval military pilot would not only have to fly but be able to navigate long distances on instruments and at night; to operate radio communications and direction finding; to handle engines of thousands of horsepower with limited fuel; to learn meteorology, gunnery, bombing, and the handling of torpedoes and rockets; and, furthermore, to cope with all kinds of emergencies such as combat damage, recognition and appraisal of enemy strength, and many other duties that would give purpose to his flying. In other words, the mere act of flying was only a part of the requirement of the military pilot, and many hours of schooling and training would have to be devoted to his education in other fields in order to make him and his flying a military asset. This staggering problem could not be met by building more training airplanes, for, aside from the load it would have imposed on the aircraft industry eventually, there would not be enough facilities, air space, or instructors to carry out the required training program for the number of pilots needed in the time allowed."

Synthetic Training

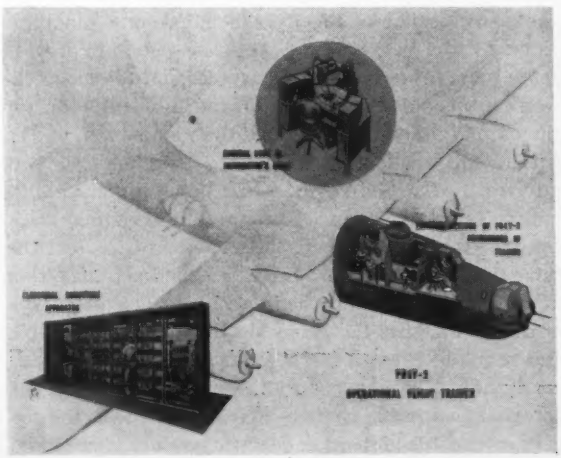
"The Navy turned to development that became known as 'Synthetic Training,' which evolved from the theory that training equipment could be built and operated on the ground to reproduce the operation of aircraft and its various functions, also to reproduce operational and combat conditions for the teaching of gunnery, bombing, radio work, etc.

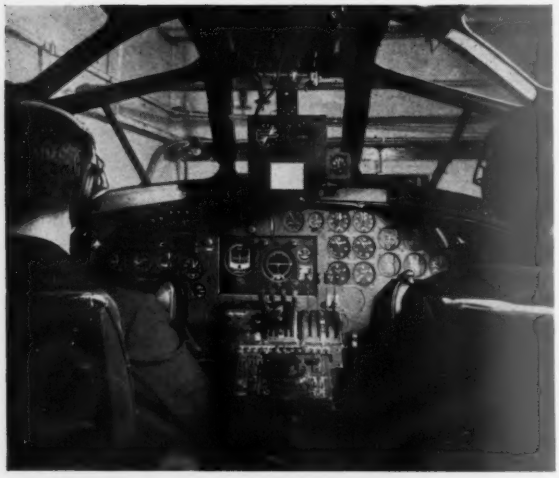
"The development of synthetic training, which began in 1941 and carried on through the war, resulted in the creation of many forms of synthetic trainers involving the expenditure of over $100,000,000. The success of this program has led to the continuation of work in synthetic training and the building of synthetic equipment which is now a permanent function of the Navy's Office of Naval Research. . . .

"The work of the Navy on flight trainers consisted of building a twin-engined mock-up provided with pneumatic computers to define the problem, transposing the pneumatic system into an electronic one, and finally led to the development of the first full-size electronic trainer in conjunction with the Bell Telephone Company laboratories. This first training device consisted of a replica of the PBM fuselage and cockpit complete with controls, instrumentation, and all auxiliary equipment, together with an electronic computing device to solve the flight equations returning the answers as readings on the instruments and reaction on the controls. This development, which began in 1942, took almost a year to complete at the cost of nearly $800,000. On completion this equipment was set up at the Banana River Air Station, operating continuously during the whole war. It served as a prototype for other electronic flight trainers, including the PB4Y (The Navy version of the B-24) and the F6F. A total of 32 electronic flight trainers were built and operated during the war. They furnished training that was not possible to give even in aircraft proper, for they permitted the operation of aircraft on instruments with such faithfulness that crews could be trained to an extraordinary degree, in addition to which they permitted the evaluation of crews and their reactions under emergencies that could not have been produced in actual aircraft."

Realistic Flight

"The fidelity with which flight could be reproduced was remarkable even in the early stages, but, of course, it was not possible to reproduce acceleration forces. It was possible, however, to introduce realistic sound effects and vibration that largely compensated for the lack of movement. The effect of sound and vibration on the ear mechanism can be made such as to create the illusion of motion, particularly when observing





instruments. In some cases limited motion can be imparted to the fuselage by supporting it on heavy springs to provide some instability to the structure. Accurate reproduction of sound and vibration is of utmost importance in the training of all personnel in the crew.....

"A striking incident attending the development of the first flight trainer was the experience of the Navy project engineer who had had no flight training—also the project engineer for the Bell Telephone Company who had had no previous experience whatsoever with aircraft before this development. They both became proficient in the operation of the trainer, and as an experiment they were both given an opportunity to fly the actual aircraft, which they had no difficulty in doing provided they remained on instruments. The Navy engineer actually took off and landed the aircraft on instruments at Banana River, in addition to flying through all normal maneuvers, without, as has been stated, ever having any flight training."

PB4Y Prototype Suggests New Computer

"In connection with the development of the PB4Y operational flight trainer, it is interesting to note that the Navy version of the B-24 included some modifications, such as an extension of the nose section to provide more room for navigational purposes and the modification of the tail to provide surface in a single fin for directional stability. Toward the completion of the breadboard models of the electronic circuit, I was advised by the Bell engineers that the directional circuit was unstable and that they would have to go back over the work to see where the trouble lay. About the same time I received word from the experimental station at Patuxent, which was then testing the first prototype of the PB4Y, that the plane was directionally unstable and required extension of the fin area to remedy this condition. The changes to the fin area at Patuxent corresponded to the changes that were made in the circuit in the breadboard model to produce directional stability. This immediately raised the possibility of designing a computer to combine the proposed flight characteristics in operating form, rather than to rely merely on figures, and thus to prove a new design one step further. This idea was approved and a project initiated to develop equipment to reproduce the flight characteristics of the proposed aircraft even before the construction of the prototype. This project is now in its final stages, and it is hoped it will be brought to successful completion in the not too distant future.

"The difficulty with such a project is that if we desire to evolve a computer that can handle any type of aircraft it becomes exceedingly complex. It is possible, however, to design a specific computer for a specific design of aircraft which will reduce the cost and the engineering to such a point where it might well be absorbed as an insurance payment for the design. Such a computer, combined with a mock-up which is normally built prior to the construction of a new type of aircraft, could be combined in the later stages of construction to produce a 'Synthetic Aircraft' which could be made to fly on instruments in accordance with the characteristics that the designers have chosen. This would not only prove out the combination of flight data but would provide the opportunity for the crew members to familiarize themselves with the new equipment and train them as a team to operate the equipment they will take off in for the first time on the initial test flight. All of this would reduce hazards and provide one more opportunity to catch defects that might prove serious, if not fatal, if encountered in flight, to say nothing of possible savings in time and alteration costs.

"The type of computing mechanism that should be used on synthetic aircraft for the proving out of flight data cannot be so simple as that which may be used for training purposes, but it presents no unsolvable problem. In computers for flight trainers it is possible to make certain compromises with actuality, such as considering certain variables to be straight line functions and approximate certain flight relationships. Such short cuts, however, would not be desirable in the simulating of the flight of a proposed aircraft of new design, since it would be necessary for the sake of certainty to reproduce the designed flight characteristic to the greatest accuracy so as to leave no known discrepancy or error in the relationship of the various factors affecting flight or control. The reason approximations are permissible in trainers for existing aircraft is because it is possible to judge their effect by comparison with actual flight and determine if they are permissible. This is, of course, not possible in the flight simulation of a new and unflown type."

Reduce Initial Hazard

"There is ample mathematical and electronic knowledge in existence today to construct 'Synthetic Aircraft' to simulate the flight of any proposed aircraft

from the design data, and thus to sum up all of the data for the designer and test pilot for preview and possibly for modification prior to the irrevocable step of test flight. By so doing we can reduce the initial hazard and provide better preparation for crews to undertake operations and cope with emergencies. The utility of a given type of 'Synthetic Aircraft' would not terminate after test flight but would continue to be valuable as a 'training ship' for commercial or military pilots and crews.

"Let us bear in mind that we are in a sense already using the idea of the computer in new designs—not actually in mechanical or electrical form but a computing device in the back of our heads which sums up all our experience and knowledge we have acquired and brings out a judgment born of weighted opinion. It has been a good computer, the best we had, and has served us well in the past. But we are coming to the era of design which hopelessly overloads the human mechanism, and it is surely time to assist ourselves with a device that can do this summation for us with greater facility and reliability.....

"A need for safety in accuracy has always existed, but, with the growth of the aircraft unit, the ability to achieve it is becoming a determining factor in aviation progress.

"Let us take one more step toward it."

Convertible Aircraft

(*Continued from page 25*)

low fuel economy during those periods become less important, and the jet-type power plant appears a definite possibility for this purpose.

There is much yet to be done. Considerable work is now in process. N.A.C.A. is investigating the efficiency of rotors as propellers and vice versa, and the problems involved in stopping and starting rotors in flight, one or other of which is a basic problem of all the aircraft we have discussed.

Other work that needs to be done includes: Analytical studies and research concerning rotor blades that become fixed wings and development of suitable airfoil sections for this type; experimental study of the dynamics and aerodynamics in the régimes of transition from lifting rotor to fixed wing, from fixed wing to autorotation, and from autorotation to helicopter; studies of tip-jet propulsion not only from the propulsion point of view alone but also the effect of weighted tips on rotor operation; more studies on single blade rotors that appear to offer numerous advantages in the convertible aircraft.

To this we could add the whole list of research problems needing solution for improvement of rotary-wing craft in general.

It was not the purpose of this paper either to solve any of the many problems confronting the designers of convertible aircraft or to evaluate in detail the merits of the various designs. Our objective has been to air the known problems and to publicize the various classes and types with the hope that by so doing greater interest will be aroused in investigating and surmounting the problems involved so that this type of craft may soon take its place in the ever expanding field of air transportation.

We believe firmly that, although research may be long and expensive, the time and cost involved in research on any given problem is apt to be only a small fraction of that expended in futile attempts at solution without it.

In closing, we wish to thank Messrs. Herrick, LePage, deMonge, Loening, and Wilford for their assistance and advice in preparation of this information.

Human Problems

in the Design and Operation of Air Transports

By
Ross A. McFarland, M.D.*

Excerpts from an Address Delivered at the I.A.S. Luncheon on January 27

"THE FUTURE SUCCESS of air transportation depends primarily on two factors—namely, improvements in safety and regularity. Many experts disagree with regard to the best methods of achieving this goal. Some believe that the human factor can be eliminated by automatic systems of flight control. My contention is that, although this may eventually be possible, at present most errors are attributed to human variables. Therefore, improvements in safety, efficiency, and regularity depend on improvements in design and operation in terms of human limitations and capabilities. If aviation is to make significant progress in the immediate future, I feel very strongly indeed that mechanical design must be more intimately related to the physiological and psychological characteristics of the operators. Air transports must be built around the air crews and passengers rather than fitting them in without due regard for their human characteristics, an occurrence that has happened so frequently in the past.

"My remarks will be oriented about the central thesis that safety depends on (1) an advance analysis of design problems in terms of human limitations and (2) operating practices that include greater insight into the characteristics of air crews. First, I will make an appraisal of the influence of accidents on the volume of traffic and try to give a few reasons why the volume of both air carrier and private flying has failed to meet postwar expectations."

Fear and Unreliability Major Factors

"What changes can be made to increase materially the volume of traffic, and why, in a relative sense, have so few persons taken advantage of air travel? There are many reasons to believe that *fear* is one of the greatest deterring factors. The frequency of accidents, especially in fields other than scheduled operations, has made the average person apprehensive. In one of the prominent Boston newspapers during the past few months, there have been almost daily reports of fatal air crashes of one type or another. This offers little comfort to the potential or seasoned air-line traveler, even though he is informed that the safety record of the domestic scheduled air lines in 1948 was bettered only three times in the past 20 years or that only 83 passengers were killed, an estimated fatality rate of only 1.41 per million passenger-miles. Fear and unreliability of operations remain major factors in discouraging newcomers, as well as experienced passengers, from using air travel. It has been estimated by one authority that each year at least 20 per cent of the air-line passengers discontinue using this mode of travel. More emphasis should be placed on publicity to overcome the apprehension of the average person...

"On the basis of number of trips per passenger as reported in traffic surveys, I have estimated that approximately 7,000,000 different people in the United States made at least one trip by air in either domestic or international operations in 1947. Warner has estimated that about 5,000,000 people elsewhere in the world used scheduled air transportation. Nevertheless, this represents only a small percentage of the total world population—that is, about one-half of 1 per cent or less than six persons per thousand. As you may know, the passenger revenue miles in 1948 showed a 2 per cent decrease over 1947..."

* Harvard School of Public Health and Member, Operating Committee of N.A.C.A., and President's Conference on Industrial Safety.

Advance Analysis of Design Problems

"My interest in the design features of air transports and their implications for air crews was stimulated by studies made during the initial flights of several new models. Many costly modifications had to be made after the planes were put into service. On one plane, for example, my notebook was filled with more than 85 illustrations of defects or modifications that were necessary or desirable. This suggests that each plane should be more thoroughly flight-tested with a full complement of passengers on various routes before being used in routine passenger service. The cost of flight testing should be equally distributed among the manufacturers, operators, and the research and development agencies of the Government. It has been demonstrated many times that faults in design, such as the changes made in the L-49 and the DC-6 after they were put into service, are eventually costly to all concerned.

"Several defects in design having a direct bearing on the working efficiency of air crews are given below. One air transport had windshields with multiple curvatures that were faired to the contour of the plane for aerodynamic efficiency and cleanliness. The distortion of pilot vision and high accident rate made it necessary to substitute flat panels and thereby make a change in the production line during the war. The plane was reduced in speed by only about 8 m.p.h., but the change in design cost millions in terms of time and money. A study of the human visual factors in a simple mock-up would have shown the error in such a design.

"A second illustration relates to the design of the navigator's table. On one transport, it not only vibrated excessively, but it was built sideways to the forward movement of the plane. In addition, the light distribution was poor in that, although there were 100 foot-candles at the back of the table, there were only 1 or 2 on the working area. These defects resulted in excessive airsickness and discomfort among the navigators.

"A third illustration may be drawn from the confusion arising when controls for operating the flaps and landing gear are too close together or are reversed from one plane to another. Inattentive manipulation or mistaken identity resulted in 547 aircraft accidents in one of the services during a 22-month period—January, 1943, to November, 1944—273 of these occurred in advanced trainers and 184 in fighters, bombers, and transports. This confusion has also occurred on commercial air transports, and I am aware of such an accident that involved one of the outstanding N.A.C.A. test pilots.

"Proof of the fact that errors may arise from defects in design may be obtained from studies of the critical components of piloting. Two recent studies have shown how these errors may occur. In one investigation at Wright Field made by Fitts, it was shown that

Table 1
Specific Pilot Acts Contributing to "Pilot Error"
(From Fitts and Gordon)

Type of Error	Frequency of Acts in Military flying	Frequency of Acts in Air-line flying
Confusion of two controls	229	31
Forgetting to operate a control	83	41
Improper adjustment of control	83	14
Reversed movement of control	27	..
Inadvertent activation of control	24	6
Unable to reach control	14	..
Total	460	92

229 of 460 specific acts contributing to pilot error were due to confusion of two controls and 83 to forgetting to operate a control. In a study of air-line pilots made by Gordon, 31 of 92 involved the confusion of two controls of 41 forgetting to operate a control (see Table 1). In other words, 68 and 78 per cent, respectively, of pilot error incidence were due to these two causes. These factors become critical toward the end of long flights under adverse landing conditions..."

How Eliminate Faults?

"How can improvements in design be brought about? In my opinion, all possible faults in equipment and in the working area of the plane, as well as the capacities of the operator, should be subjected to an *advance analysis* for preventing accidents. If defects are present, it is only a matter of 'time' before some operator 'fails' and has an accident. Advance analysis assumes the following considerations. The first involves an operational job analysis that should include a survey of the nature of the task, the work surroundings, the location of controls and instruments, and the way the operator performs his duties. The second implies a *functional concept of accidents*—that is, it anticipates the errors that may occur while the operator is working at the machine. The repetition or recurrence of near or real accidents clearly indicates a need for redesigning. A third consideration relates to *human limitations*. It should be assumed that no pilot is a perfect one. In fact, he may be far below the ability as judged by the designer. If his duties are too complex, the cumulative burden is great and he reaches or exceeds his limits of attention and ability. Finally, a wide *margin of safety* should be provided to eliminate any possible situation that places the pilot near his maximum ability with regard to aptitude or effort, especially when adverse factors enter the picture.

"If the principles of advance analysis had been applied to a study of air-crew duties in the larger transports, the present difficulties with regard to the requirement of a flight engineer's station might have been avoided...

"The advantages and disadvantages of including a flight engineer's station in the cockpits of large transports have been discussed in my book on *Human Factors in Air Transport Design*. The only questions

that are being raised here are: (1) Why was the decision made to use a flight engineer *after* several large transports had been built and certificated for service in domestic operations using a two-man crew? (2) Why was an 80,000-lb. maximum take-off weight taken as a criterion for the necessity of having a flight engineer? (3) Furthermore, will the above regulation handicap the designers in simplifying cockpits, especially when turbine or jet engines may be introduced in the near future? An advance analysis of the requirements of the air-crew duties with respect to time, especially during take-offs and landings, might have revealed an answer to this problem *before* rather than *after* the planes were put into service. Because of the large number of changes that are made during the development of each model, such studies should be made in the manufacturing setting. A continuing job analysis of the effect of each change on the performance of the air crews would provide relevant data on both technical and operating problems..."

Methods of Accomplishing Objectives

"Several methods of accomplishing some of the objectives outlined above are as follows: (1) Aeronautical engineers should be given a special course in human factors of aircraft design in their basic college training. (2) Each operating air line might find it advantageous to have a flight safety engineer whose duties would include a tabulation and systematic analysis of errors in design and operation. With a background in engineering and flight training combined with a close liaison with air crews, ground maintenance units, and Government agencies, such experts might help to improve flight safety practices and procedures. (3) Defects in design and near accidents should be made known to a central coordinating agency and redistributed to all air-line operators and aircraft manufacturers. Effective steps in this regard are being made by the C.A.A. and other agencies. (4) Further attempts should be made to simplify and standardize cockpits and equipment through the appropriate air-line agencies and scientific groups in order to present the manufacturers with uniform requirements and recommendations.

"In summarizing my point of view with regard to design problems in air transports, I should like to pay a tribute to the aeronautical engineers. In many instances, they have been blamed for errors that should have been attributed to others. Naturally, they build according to specifications provided for them, and only recently have they been given reliable information relating to human factors. Physiologists and psychologists should do more to provide adequate design criteria or limits of acceptability in order that this knowledge may be incorporated into the original design of aircraft. Safety and comfort can be greatly improved once the experimental basis for each of these variables is known and adequate teamwork in various fields of science is achieved."

Advance Analysis of Human Problems in Airline Operations

"Since it is unlikely that marked improvements in cockpit simplification can be incorporated in present models, some consideration should be given to the human factors in air-line operation. One of these relates to the selection and training of air crews and another to the maintenance of fitness under all types of operating conditions, especially during the last 5 min. of flight. These two areas are selected for discussion because of their direct relationship to improvements in safety. Air crews with superior ability and training are required for the newer models, which are larger and faster. Furthermore, airports are becoming more crowded, and approach patterns are flown at greater speeds. Thus there is need not only for more detailed information concerning the critical requirements of a pilot's job but also more insight into the factors that may influence him adversely at a time when accidents are most likely to occur—namely, when landing. It follows logically that, if faults in design are present or a task is more difficult, a higher type of airman is needed, more training is required, and a greater degree of crew coordination should be obtained.

"There are two chief aspects of selection. One concerns psychological fitness, including aptitude and temperament; the other, medical fitness as it relates to the tasks to be performed. It is rather surprising that so little data are available with regard to what is expected of a pilot, objective methods of appraising his ability, and follow-up studies of his success.

"The value of determining psychological fitness at the time of selection was demonstrated by a study of 300 potential air transport pilots in Boston in 1941. They were given a series of psychological tests at the time of entering an advanced training program. No one was disqualified on the basis of these tests, but a great deal of time and expense might have been saved if those who made the poorest scores had been eliminated. A checkup of the candidates 8 years later showed that several of the tests were capable of predicting success and failure but that upper as well as lower cutoff limits might have been desirable. For example, extremely intelligent, well-coordinated, and emotionally stable candidates who made high scores in the tests all became capable pilots, but many of them left the air lines through lack of interest. On the other hand, some of those who made the poorest scores went from one company to another and finally became chauffeurs and mechanics. Although the tests failed in certain individual cases, in terms of statistical averages they predicted success or failure in transport flying successfully. The fact that one large operating company has a turnover rate of about 10 per cent in their flight group each year indicates the need for giving more attention to selection of air crews...

"In recent years, much confusion has existed with regard to standards of physical fitness for pilots. Some advocate greater leniency or even the elimination of all

medical requirements for the private pilot, while others would be more strict. Those who argue for greater leniency point out the inconsistency in the findings of various medical examiners and a lack of definite relationship between physical defects and accidents. I submit that this does not mean that standards should necessarily be lowered but that a sounder basis of relating physical requirements to performance on the job be developed. Some progress is being made in this regard, and hearing standards will be discussed as an example.

"In establishing physical standards for hearing in air-line pilots, several considerations should be kept in mind. One relates to the precise measurement of auditory defects, a second to the requirements of the job—that is, what signals must be heard during flight—and a third to the design of equipment as it relates to the hearing losses that are most common. Audiometric tests for determining the amount of hearing losses should be given and related to what a pilot is expected to hear—namely, the human voice (frequencies up to about 3,000 cycles per sec.), the radio beam (about 1,200 cycles per sec.), and fan and cone markers (about 3,000 cycles per sec.). In connection with the last, it should be noted that there is a visual signal on the panel, as well as the oral one. Some hearing losses can be offset by signal amplification.

"Many of the older pilots show fairly great losses in the higher frequencies—that is, above 3,000 cycles per sec.—but if no new signal frequencies are introduced above this range no difficulties will be encountered by most of them. In fact, those who are quite deaf to the higher frequencies have more normal hearing in the presence of noise on the aircraft because of the 'recruitment' phenomenon and masking effects. Without compromising with regard to safety, we now feel that no pilot should be grounded for poor hearing unless he is given a practical flight test to determine if he can hear the necessary signals in flight. This is not only fairer to the pilot but relates the test to the performances of his duties.....

"Not many months ago, a bill was introduced in the Massachusetts Legislature to limit the licensing of aircraft pilots to those who were 50 years of age or younger. This followed as the result of a fatal accident to a private pilot who was 60 years of age. There is little evidence to support such a drastic step in the interests of safety, however. In the first place, there is no direct correlation between frequency of accidents and age in either private or commercial flying. Of approximately 3,000 captains or supervisory pilots in 1946, 388 or 13 per cent were 40 or over, 157 or 5 per cent were 45 or over, and 53 or 1.8 per cent were 50 or over. By 1950, about 800 of all those who held C.A.A. medical certificates in 1946 will be more than 40 years of age and 335 will be over 45. Although there may be isolated cases in which the older pilot gets into trouble, there is no reliable evidence from air-line experience to indicate that the older pilots make most of the errors. On the whole, variables other than age are much more important causative factors in accidents.

"Based on present impressions, 50–55 years may be a reasonable age for retiring air-line pilots. If this range is accepted, a considerable discrepancy exists between this figure and that which has been calculated for most air-line pilot retirement pension plans. In my opinion, it is premature to set definite age limits for retirement. Each case should be judged on the basis of 'functional fitness' rather than on chronological age alone."

Operational Aspects of Fatigue

"In one well-controlled study carried out in England, pilots were subjected to a fatiguing flight in an elaborate mock-up of a cockpit. All essential forces and stimuli, other than extreme acceleration, were simulated in the experimental setting. One of the findings was that as men approached the end of a fatiguing experiment, if they were informed that the end was near at hand, they relaxed and errors increased sharply. The type of errors that occurred related to making fine motor adjustments or the timing of maneuvers—that is, while they retained the basic pattern of flying skills, the fringe skills, which make for good technique and safety in the final approach, deteriorated. The loss of fine coordination and timing was complicated by a parallel decline in standards of performance—that is, the pilots realized they were performing more poorly but because of their fatigue were willing to accept it as satisfactory. Also they failed to integrate the flight instruments as a whole or as a unit but first looked at one and then another.

"In this study, the effort imposed on the pilot was a concentrated one. They were flying in a single-seater cockpit, and fatigue was brought on extremely quickly—that is, within 3 or 4 hours. The 350 pilots used as subjects were divided into three groups regarding accident frequency. Those showing the least deterioration had only one accident in 5,300 flying hours, while those showing the most had one accident in 400 hours or a rate 13 times as great. While the onset of fatigue would not be so rapid in a transport plane, it might be just as inevitable if the flight is of sufficient duration or difficulty, especially if complicated by adverse weather or mechanical defects.

"In conclusion, it is my feeling that the volume of air-line traffic has failed to expand in accord with postwar expectations primarily because of the large number of accidents in all fields of aviation. As a result, feelings of fear and apprehension are widespread. Since many accidents are attributed to human error, it is suggested that improvements in design might be brought about by a thorough advance analysis of every possible source of error. High standards of selection and training are also found to be essential in improving the operating record. Special emphasis is placed on maintaining high standards of alertness, skill, and fitness during approaches and landings after long or difficult flights."

I.A.S. Seventeenth Annual Meeting

Technical Sessions

Part II*

DR. ALEXANDER KLEMIN†
Aeronautical Consultant

Synthetic Aircraft

WILL ROGERS, the great American humorist, used to say, "All I know is what I read in the papers." It would not be true to say that the daily press will tell us all that the Institute Meeting brings forth in science and technology, but newspapermen have a flair for the significant. Accordingly, when the *New York Times* devoted a half-column editorial to the luncheon speech of Adm. Luis de Florez, it was because this engineer, with so many wartime training devices and methods to his credit, had once again evolved a valuable idea, a "Synthetic Aircraft" to serve in the development and testing of new airplanes. During the war the Navy developed and used Synthetic Aircraft for training men in gunnery, bombing, radio work, meteorology, and the handling of rockets and torpedoes. Moreover, with the aid of complex electronic devices, computers, and electric analyzers, it was possible to subject young pilots, in almost uncanny fashion, to simulated emergency conditions, the cutting out of an engine, combat damage. The Navy spent $100,000,000 on its synthetic trainers and saved millions of hours of training time and billions of dollars. In pioneer days, to build a new plane cost a few thousand dollars, and in the test flight only one man risked his life. Today the first flight hazards millions of dollars and the lives of several men. Admiral de Florez suggested the building of synthetic aircraft to reproduce the flight characteristics of a new machine in operating form rather than to rely on calculations, however learned they might be. Excerpts from Admiral de Florez' talk will be found elsewhere in this issue.

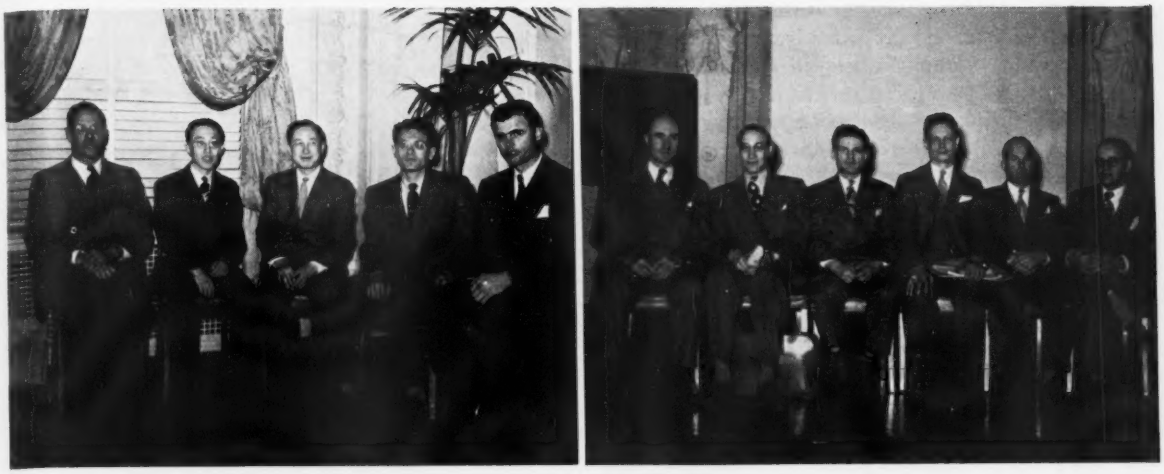
Fluid Mechanics

Ever since Prandtl's famous paper, dated 1904 (speaking from memory), in which he gave his first conception of the boundary layer, that narrow and important region where viscosity has full play, the boundary layer has been the subject of continuous and intense research, and rightly so, because all aerodynamic phenomena seem to originate within the boundary layer. It is not surprising, therefore, that the Fluid Mechanics Session offered two papers mainly concerned with what happens in this interesting region.

The first of the two papers was one by Prof. H. S. Tsien and M. Finston (Massachusetts Institute of Technology) on "Interaction Between Parallel Streams of Subsonic and Supersonic Velocities." The completely subsonic flow region yields to mathematical analysis, so does the completely supersonic case. It is in the transonic case, when subsonic and supersonic streams appear simultaneously, that difficulties arise. The following is a *crude oversimplified statement*. Suppose there is a supersonic flow over an airfoil and a region close to the boundary in which there is a retarded, subsonic flow. Suppose that there is a shock in the supersonic flow and an increase in pressure. The pressure due to the shock will act ahead through the subsonic region, create an adverse pressure gradient and, hence, cause separation of the boundary layer The airfoil will experience a double source of drag, one due to the shock and the other due to the tearing away of the boundary layer, which is deplorable. Another characteristic of the phenomenon is the so-called λ shock. The phenomenon is complex with compressibility, shock effects, viscosity effects, heat transmission effects, all adding up to bewilder the analysts, many of whom have already worked on the problem with incomplete success. Tsien and Finston continue the search for an adequate explanation. They assume a simplified model: The boundary layer is replaced by a uniform subsonic stream of finite width, bounded on one side by the solid wall and on the other side by the interface with the uniform supersonic stream of infinite extent. The flow fields of two cases are analyzed in detail; (a) a compression wave in the supersonic stream incident upon the subsonic layer, and (b) outgoing compression waves generated by a sudden change in the slope of the solid wall. Both types of disturbances are assumed to be small, so that linearization of the differential equations is possible. A general result is that the distance of upstream propagation is directly proportional to the width of the subsonic layer. Therefore, when the boundary layer is turbulent and the subsonic layer is extremely thin, there is negligible softening of the shock. By their skillful use of perturbation methods they have advanced knowledge, even if they have not arrived at a complete solution.

* This covers the last 2 days of the Technical Sessions.

† Helicopter Editor, *Aero Digest*, and Editor, *Handbook of Aeronautical Engineering*.



Fluid Mechanics Panel: *Dr. Clark B. Millikan, Chairman; S. I. Pai, Cornell Aeronautical Laboratory; H. S. Tsien, Professor of Aerodynamics, Massachusetts Institute of Technology; John Laufer, California Institute of Technology; and Dean R. Chapman, Ames Aeronautical Laboratory, N.A.C.A.* **Structures—Dynamic Loads:** *Chairman J. P. Den Hartog, Professor of Mechanical Engineering, Massachusetts Institute of Technology; Martin Goland, Chairman, Engineering Mechanics Division, Midwest Research Institute; Yudell L. Luke, Research Mathematician, Midwest Research Institute; Manfred Rauscher, Associate Professor of Aeronautical Engineering, Massachusetts Institute of Technology; J. E. Wignot, Structures Engineer, Lockheed Aircraft Corporation; and Reinhardt M. Rosenberg, Associate Professor of Aeronautical Engineering, University of Washington.*

The second paper concerned with the boundary layer by Dean R. Chapman and Morris W. Rubesin (Ames Aeronautical Laboratory) was entitled "Temperature and Velocity Profiles in the Compressible Laminar Boundary Layer with Arbitrary Distribution of Surface Temperature." As a rule we think of the laminar flow as associated with slow speeds or with superpolished specially designed airfoils and so not likely to be encountered in practical flight. We are wrong. Recent theoretical investigations of the stability of laminar boundary-layer flow have shown that it is possible for extensive regions of laminar flow to be maintained at supersonic velocities even though the Reynolds Number is extremely large. Calculations indicate, for example, that in the absence of adverse pressure gradients the cooling due to radiation alone at a Mach Number of 3 and at 50,000 ft. altitude can be sufficient to stabilize the laminar boundary layer regardless of Reynolds Number. These predictions of the stability theory have not as yet been quantitatively verified by experiments, but there is little doubt as to their qualitative correctness. Consequently, the characteristics of the laminar boundary layer have recently assumed a much greater degree of importance to the engineer than was the case in the past. The maintenance of extensive laminar flow is, of course, highly desirable in order to minimize the friction drag as well as the cooling requirements resulting from aerodynamic heating.

It is with these premises that the authors undertook their investigation. They have presented an analysis that enables the temperature profiles, velocity profiles, heat transfer, and skin friction to be calculated for a two-dimensional or axially symmetric surface without pressure gradient but with an arbitrary continuous distribution of surface temperature. The general theory is applicable to a gas of any Prandtl Number, although the numerical results given herein are applicable only for air ($Pr = 0.72$). Their theory enables heat-transfer and skin-friction calculations accurate to within about 5 per cent to be made for flight conditions up to Mach Numbers near 5 and to within about 1 or 2 per cent for supersonic wind-tunnel conditions up to considerably higher Mach Numbers. They made a particular effort to present the results, which are quite simple considering their generality, in a form that can be readily used in practical applications. They worked out in detail an example that illustrates some of the principal effects of variable surface temperature and show that both positively infinite and negatively infinite heat-transfer coefficients can occur. The anomaly of infinite and negative heat transfer is attributable to the customary definition of the heat-transfer coefficient which is fundamentally inappropriate for flows with variable surface temperature. In the particular example considered, the conventional method for calculating the net heat transferred yields completely incorrect results. To facilitate the use of the results, all of the principal equations developed are collected and summarized in a section entitled "Practical Use of Results."

S. I. Pai (National Central University, China, and Cornell Aeronautical Laboratory) wrote on an equally important topic, the "Two-Dimensional Jet Mixing of a Compressible Fluid." The problem of the flow of a jet of a compressible fluid exhausting into a uniform stream is of theoretical interest and of practical importance since there are turbojet engines. In this

paper both the laminar and the turbulent flow of two-dimensional jet mixing are investigated theoretically. In high-speed flow from a jet engine, the density of the fluid is low and its temperature is high so that the kinematic viscosity is large; hence, the resulting Reynolds Number is small, in spite of the high speed. At small Reynolds Number, a considerable portion of the jet should be laminar. Hence, a solution assuming laminar flow is of some practical interest, and the results for laminar flow are applicable to turbulent flow, provided that the empirical quantity of eddy kinematic viscosity has been experimentally evaluated. Turbulent flow is usually important in most practical cases, but we have to use the so-called semiempirical theory to analyze the turbulent flow. In this paper, Reichardt's theory of free turbulence has been extended to the case of a compressible fluid.

In the first part of the paper the flow is assumed to be laminar. It is shown that if the velocity in the jet differs slightly from that of the surrounding stream, using the method of small perturbations and the ordinary boundary-layer assumptions, the equation of motion of two-dimensional flow reduces to the form of the well-known equation of heat conduction, whose solution is known for any given boundary conditions. Solutions are obtained for the mixing of two uniform flows and for a jet of compressible fluid from a two-dimensional nozzle with complete expansion exhausting into a supersonic stream. They are expressed in terms of Gauss's error integral. By a transformation similar to that used by von Kármán and Tsien, it is shown that the exact solution of the two-dimensional jet mixing of a viscous compressible fluid can be obtained by successive approximations, starting with the solution obtained from the above-mentioned method of small perturbations.

The author worked out numerical cases of a hot jet in a cold stream, cold jet in a hot stream, large velocity difference, and a case where small perturbations are valid. He also gives some interesting figures for the mixing of the two uniform streams. From a practical point of view, this is only a beginning. The next step is to connect this elegant theoretical work with the thrust and propulsive efficiency of a turbojet engine.

For the remaining paper of the Fluid Mechanics Session, "Some Recent Measurements in a Two-Dimensional Turbulent Channel," by John Laufer (California Institute of Technology), we can do no better, for lack of the paper itself, than to quote the summary given by the author:

"The paper describes detailed measurements of mean and turbulent velocity fields in a two-dimensional fully developed turbulent channel flow, including distributions of velocity fluctuations, correlation coefficients, turbulent scales, and microscales. It presents results of measurements in the laminar sublayer and discusses Reynolds Number effects on the turbulent velocity field. The distribution of the various turbulent energy terms across the channel is also obtained."

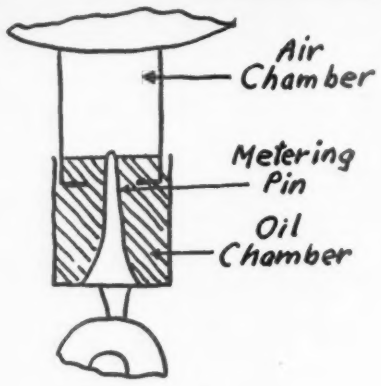


FIG. 1.

Structures—Dynamic Loads

Landing Gears

Once upon a time, in the days of aeronautical innocence, structural analysis meant static analysis. Flutter had not been heard of, and the life of airplanes was so short that fatigue loads had no importance. In recent times, distortion has brought the new word "aeroelasticity," and the Structures Sessions were divided into two—Dynamic Loads and Static Loads—with the Dynamic Loads coming first to show perhaps where the emphasis lies in structural engineering today.

Certainly the paper by Prof. R. M. Rosenberg (University of Washington) on "A New Approach to the Design of Metering Pins in Oleo Struts" came under the dynamic load classification. Oleo struts have been going a long time, drop test records and empirical methods have given practical solutions but *not* an adequate theory. Professor Rosenberg's paper is likely to fill the gap for the reasons that follow: Fig. 1 shows the essential elements of the oleo strut, which is a combination air spring and fluid damper. Collapsing of the strut compresses the air in chamber and forces the damping fluid through the orifice. The orifice area is varied during the stroke by means of the metering pin that projects through the orifice. The diameter of the metering pin is a function of its length, and design of the metering pin presents the essential difficulty and also the essential feature of oleo design, because the metering pin controls the rate at which energy is dissipated. In the past, the approach has been to simplify a nonlinear problem until it was amenable to mathematical treatment or to treat the unsimplified problem by numerical or graphical methods. The first is so unrealistic that it bears little resemblance to the physical problem at hand; the second method lacks generality. "Both methods," says Professor Rosenberg, "have as a goal the integration of a differential equation that is so strongly nonlinear that the possibility of finding a general solution can be confidently regarded as hopeless." It is in the application of nonlinear methods that the main interest of Professor Rosenberg's paper lies, and he sets up the differential

equation without simplification. To solve this equation end he employs the substitution $V^2 = y$ and studies the trajectory in the phase plane, where the velocity V is plotted against the displacement x. As a criterion of design Professor Rosenberg states that the basic condition that will be satisfied is that the integral of the square of the vertical acceleration with respect to the stroke shall be a minimum. The physical concept behind this requirement is that the vertical acceleration is a direct measure of the vertical force acting on the airplane. But his method would be applicable for any other criterion and is the more valuable on that account.

There was another paper concerned with the landing gear—"Landing Gear Oscillations Due to Unstable Skidding Friction" by J. E. Wignot and Frederic M. Hoblit (Lockheed Aircraft Corporation). This paper was as welcome as Professor Rosenberg's, because it also dealt with a thoroughly practical engineering problem. In recent years there have been heretofore unexplainable landing-gear service failures occurring while the airplane was skidding on a wet runway. A possible cause of such failures is the occurrence of self-induced oscillations of the gear. The purpose of the paper was to present a quantitative theory of such self-induced oscillations. The authors considered many factors and used sound methods of dynamic analysis. For their detailed study they took the following service condition: An airplane is moving straight forward on a level runway with constant vertical load on the gear and with the brakes locked so that the wheels are skidding. Some disturbance is then encountered, such as a rough spot in the runway, which imparts motion to the landing gear. The problem is to determine the nature and magnitude of this motion and the magnitude of the drag loads which the landing gear experiences as a result. Apparently the results of the theory have been checked by experimental observations. Hence, engineers will accept and study all the more carefully the excellent conclusions arrived at by the authors:

"Landing gears may experience large oscillatory drag loads under service conditions if the coefficient of friction decreases with increasing velocity of slip. The magnitude of such drag loads is substantially independent of the source and magnitude of the initial disturbance. An increase in the equivalent static load on the gear, or in the slope of the friction coefficient vs. velocity curve, increases the probability of the oscillation and the rate at which it builds up. An increase in the damping decreases both the probability of the oscillation and the rate at which it builds up. An increase in mass (stiffness remaining constant) increases the drag loads and stresses throughout the landing-gear structure. An increase in stiffness (mass remaining constant) increases the drag loads. Such increase in stiffness ordinarily involves an increase in strength of the parts being stiffened, so that the drag stress in these parts is decreased. The drag stress in all other parts of the landing gear is increased. An increase in frequency of oscillation (as produced by variation in stiffness or mass or both) decreases the displacement amplitude of oscillation, may increase or decrease the drag loads, and ordinarily decreases the drag stress in parts which affect the stiffness."

Thus the authors present a coherent, trustworthy theory. What remains to be done? (1) Investigate the variation of coefficients of friction with velocity of slip, particularly at high speeds. (2) Find a way of estimating structural and other damping *before* the landing gear is built. (3) Consider seriously the introduction of large hydraulic damping into the system.

Aeroelasticity

The organizers of the Annual Meeting chose to divide the Structures Sessions into Structures—Dynamic Loads and Structures—Static Loads. We choose to divide the Structures—Dynamic Loads still further into Landing Gear and Aeroelasticity.

Aeroelasticity is a newcomer in aeronautical terminology and a thoroughly justified one. Martin Goland and Yuddell L. Luke (Midwest Research Institute) define aeroelasticity so well that we cannot resist quoting:

"A significant trend in current aeronautical engineering practice is the growing detail with which a variety of dynamical problems must be treated. Whereas in the past it has been possible to approach a design almost soley on the basis of satisfying certain pseudostatic operating conditions, when modern high-performance aircraft are involved many instances arise where this point of view must be discarded; in its place, a realistic consideration of the craft as a free body in three-dimensional motion is necessary. This trend is particularly evident in certain problems in the fields of stability and structures, where the complexity of questions relating to handling qualities, maneuverability, and dynamic loads has increased to the point where the simplified pseudostatic approximations no longer apply. Examples of such problems are found in the study of the aircraft behavior in gusty air, the dynamical loads induced during landing, and the effects of aeroelasticity during high-performance operation."

The authors devoted their paper to a study of the natural modes only. They established the general stability determinant for an aeroelastic system involving wing bending vs. wing torsion and derived the equations of motion by making use of the Wagner air forces, which presume a potential flow of an incompressible fluid past a thin, two-dimensional airfoil in unsteady motion. They show how the roots of the stability determinant can be extracted in a relatively simple manner, enabling a description of the natural modes, and present sample calculations for a number of aircraft wings over speed ranges from zero air speed up to the flutter speed. The simplicity of the method is valuable. The conclusions are even more valuable. They find that the damping in the critical mode increases with air speed until at least 85 per cent of the critical speed is attained; it then rapidly decreases to the flutter value of zero. The noncritical mode encounters a sharp increase in stability in the proximity of flutter.

Structures—Static Loads: *Chairman Nicholas J. Hoff, Professor of Aeronautical Engineering, Polytechnic Institute of Brooklyn; A. E. McPherson, Materials Engineer, Engineering Mechanics Section, National Bureau of Standards; John E. Duberg, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A.; S. B. Batdorf, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A.; and P. P. Bijlaard, Professor of Applied Mechanics, Polytechnic Institute of Delft, Holland.*

A comparison made between the normal mode characteristics and the system response due to forced excitation shows that the latter gives an earlier indication of the approach to a critical state. Therefore, this final conclusion emerges: *flight-flutter testing is best carried out using the forced vibration technique.*

The other paper in the realm of aeroelasticity, "Station Functions and Air Density Variations in Flutter Analysis" by Manfred Rauscher (Massachusetts Institute of Technology), was also concerned with methods of analysis. The thoughts that lead to the Station Function scheme of Part I of the paper are of interest. The replacement of distributed masses by concentrated masses is often used to simplify the dynamic analysis of continuous bodies. In comparison with continuous-function methods of the Rayleigh-Ritz-Stodola type, such a method is both crude and laborious, but it has the advantage of requiring little judgment and of remaining workable under conditions too complex to be handled in other ways. The author had a fine conception. He thought that continuous-function features might be grafted on the concentrated-mass plan to increase the accuracy and reduce the laboriousness of the plan. He investigated the possibility of such a combination and arrived at the Station Function scheme presented in his paper.

The tie-in is analogous to that between the ordinates of a curve at a series of stations in the development of Simpson's Rule. The use of the Functions combines the conveniences of working with discrete masses and of having continuously defined deflections. Examples show the Functions to serve well both for the calculations of vacuum modes and for the determination of flutter modes.

In Part II of the paper the author explains clearly why he uses air density as a variable in flutter calculations. The idea of treating the air density as a disposable parameter in flutter calculations was first considered as part of a plan of working from vacuum modes to flutter modes through stepwise air density adjustments. This plan contemplated the use of Taylor expansions of the flutter characteristics in terms of the air density at the successive stages and extrapolation from each stage to the next. Difficulties with infinite derivatives were found to hinder the crucial start from zero density; but once a finite density had been reached, the process, while rather cumbersome, proved readily workable. Turning away from the vacuum or zero density start idea for the time being, the study then went on to explore ways in which the density variation plan might be made an economical part of regular flutter computations.

Air density variations were considered as a means of fixing the flutter conditions corresponding to a chosen value of the flutter parameter k. The attractiveness of the scheme lies in its automatic coverage of the flutter performance at various altitudes and in its avoidance of calculations for hypothetical sets of frequencies and air speeds at air densities fixed in advance.

Structures—Static Loads

Plastic Buckling

Just as it appeared logical to divide the Structures—Dynamic Loads Session into two parts, so it appears appropriate to divide the Structures—Static Loads papers into two groups, with Plastic Buckling as the first.

Once upon a time when the stress in a section of a column had passed the yield point, the stress analyst admitted failure, concluded that the column could go no further in strength, and gave up further analysis. In the complexity of modern aeronautical structures, such simplicity is untenable. Conditions exist where with extremely high loads or high loads of relatively long duration, the Sheet may pass into the plastic range and yet continue to contribute to the strength of the airplane. Fortunately for aeronautics, when the time came to take plasticity into account, scholars in applied mechanics and investigators in the mathematics of geological slips and faults were there to help. There is at present an enormous literature of the "plastic region" in aeronautics as well as outside of aeronautics.

S. B. Batdorf (Langley Aeronautical Laboratory) adds worthily to this literature in his paper "Theories of Plastic Buckling." He develops a new theory, relates it to experiments, and explains many paradoxes of buckling behavior. Mr. Batdorf gave a review of the present theories of plasticity which will serve as an introduction not only to his own paper but to the companion paper by Prof. P. P. Bijlaard (Polytechnic Institute of Delft) on "Theory and Tests on the Plastic Stability of Plates and Shells."

"That even a perfect column can buckle according to a tangent modulus law is rational and acceptable on

the basis of intuitive argument. The buckling stress of a column depends upon its stiffness against bending. In the elastic range the stiffness is the product of E, the elastic modulus, and I, the moment of inertia of the cross-section. Beyond the elastic range the stiffness depends upon the stress and also on the rate of increase or decrease of compressive stress accompanying the bending. The effective modulus at a given stress may be anything between the elastic modulus (which applies if the relative rate of unloading and bending is such that all portions of the cross section are unloading) and the tangent modulus E_T (which applies if the relative rate of loading and bending is such that all portions of the cross section are loading). Since a structure always buckles in the mode associated with the lowest buckling stress, and the minimum buckling stress of the column is associated with the minimum bending stiffness, the effective modulus in plastic column buckling is the tangent modulus.

"Mathematical theories of plasticity take as their point of departure the stress-strain law for simple tension or compression. In the elastic range, the relation between the stress σ and the strain ϵ is essentially linear and is expressed by the equation

$$\sigma = E\epsilon \tag{1}$$

Beyond the elastic range, two methods of representation are used. In one, the finite relationship is retained between stress and strain, but the elastic modulus E is replaced by the so-called secant modulus E_S, which varies with the stress, so that Eq. (1) becomes

$$\sigma = E_S\epsilon \tag{2}$$

The other mode of representation is an incremental one employing the tangent modulus E_T, which also varies with the stress. The mathematical expression of this law is

$$d\sigma = E_T d\epsilon \tag{3}$$

Eqs. (2) and (3) apply as long as the loading continues to increase. Unloading, however, occurs elastically—that is, Eq. (3) applies with E_T replaced by the elastic modulus E, so that the relation between stress and strain during unloading is a straight line parallel to the elastic portion of the stress-strain curve.

"The various theories of plasticity seek to generalize these results so as to formulate correctly stress-strain relations under complex loading conditions in the region beyond the elastic range. Those that have been proposed up until the present time can be classified into two types, one of which generalizes Eq. (2) and therefore involves relations of the finite type, while the other generalizes Eq. (3) and therefore involves incremental relationships. The theories involving finite laws are sometimes called deformation theories and those involving infinitesimal laws, flow theories. Both types of theory assume that the plastic law proposed applies during loading while unloading occurs elastically. Whether the change in the stress state constitutes loading or unloading is supposed to depend upon whether the change increases or decreases a rotationally invariant function of the stresses. This function, which is sometimes termed the 'stress intensity,' is usually assumed to be proportional either to the maximum shear stress or to the so-called octahedral shear stress, which is related to the energy of distortion. In order to make a plasticity theory definite enough to be mathematically tractable, additional assumptions must be introduced, and these ordinarily include the assumption that the principal axes of stress coincide with the principal axes of the plastic part of the strain or its increment."

With regard to the more novel part of Mr. Batdorf's paper, the following too concise statement will have to suffice: The theory for the plastic buckling of columns, which appears finally to have achieved a satisfactory form, rests upon the well-established uniaxial stress-strain relation. The development of a correspondingly satisfactory theory for the plastic buckling of plates has been hampered by the nonexistence of an established polyaxial stress-strain relation in the plastic range.

Present theories for the polyaxial stress-strain relation beyond the elastic range can be divided into flow and deformation theories. Theories of plastic buckling based on deformation theories are in better agreement with experiment than those based on flow theories. On the other hand, tests in which a material is compressed into the plastic range and then subjected to shear at constant compressive stress are in better agreement with flow than with deformation theories. Legitimate doubt therefore has existed as to the validity of any theory for the plastic buckling of plates.

As a result of studying these apparent contradictions, the author has developed a new theory of plasticity which is of neither the flow nor the deformation type. It is based upon the concept of slip, and its formulation was guided more by physical and less by mathematical considerations than previous theories. Experimental evidence of limited scope but of crucial character is in better agreement with the new theory than with either flow or deformation theories. The new theory accounts for the apparent contradictions previously alluded to and justifies the use of deformation theory in the analysis of plastic buckling problems.

While Professor Bijlaard's paper was highly mathematical, it *does* develop practical design formulas for plates and shells having various edge conditions and subjected to different loadings when they buckle under stresses exceeding the elastic limit of the material. With buckling of plates and shells another state of stress is superimposed on the original one. The author assumes that local plastic deformations are governed only by the amount of elastic shearing energy at the point in question and shows that the assumption of "plastic deformation" leads to smaller buckling stresses than that of "plastic flow." Therefore he makes a first assumption, by which his formulas include also the latter as a special case ($e = 0$). This assumption proves to be in agreement with the actual behavior, and the results of tests by Kollbrunner (1946) and by

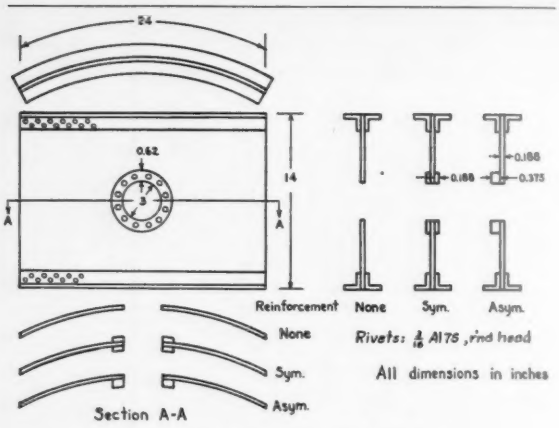


FIG. 2. Nominal dimensions of panels.

the N.A.C.A. (1945–1946) are indeed in exact agreement with the author's theory of plastic stability. The ratio between plastic and elastic buckling stress is the higher the more the ratio of the deviator components, as superposed by buckling, differs from that of the original deviator components. The stress-strain relations are derived by writing the infinitely small excess strains as total differentials and computing the partial derivatives of the strains with respect to the stresses. After derivation of the differential equation for plate buckling, the results are given of its application to several kinds of loading and boundary conditions. Also the plastic collapse of deep-well casing is included in the theory. The buckling of shells is also dealt with. It is shown that the stress-strain relations as derived by Ilyushin (1944), Stowell (1948), and Prager (1948) were already included in the author's theory (1938) but give too high buckling stresses because of the fixation of some of the variables and assuming the deformations with buckling partly elastic.

FIG. 3. Test setup.

Holes and Shells

One is so accustomed or hardened to highly mathematical papers on Structures before the Institute that it is almost a shock to read a paper that is mainly experimental. And at that the paper on "Compression Tests of Curved Plates with Circular Hole Reinforced with Doubler Plates" by Wilhelmina D. Kroll and Albert E. McPherson (National Bureau of Standards) had a strongly mathematical background, since it was based on the plane stress theory for the stresses and displacements in the neighborhood of a reinforced hole in an infinite flat sheet. The effect of curvature was neglected in the analysis, since no theory for curved sheet with a reinforced circular hole was available. The following equations are given here because they are apparently quoted from an unpublished report:

$$\epsilon_r = (1/E)\{F(1-\nu) + K(1+\nu)a^2/r^2 + [-A(1+\nu) - 6\nu Br^2/a^2 - 3C(1+\nu)a^4/r^4 - 2Da^2/r^2]\cos 2(\theta+\psi)\} \quad (1)$$

$$\epsilon_\theta = (1/E)\{F(1-\nu) - K(1-\nu)a^2/r^2 + [A(1+\nu) + 6Br^2/a^2 + 3C(1+\nu)a^4/r^4 + 2D\nu a^2/r^2]\cos 2(\theta+\psi)\} \quad (2)$$

$$u_a = (a/E)[F(1-\nu) - K(1+\nu) - A(1+\nu) - 2\nu B + C(1+\nu) + 2D] \quad (3)$$

where

a	=	radius of hole
r	=	distance from center of hole
$(\theta - \psi)$	=	angle between direction of compressive stress far from the hole and direction from center of hole to point where r is desired
E	=	Young's modulus
ν	=	Poisson's ratio, 0.3
A, B, C, D, F, K	=	constants to be determined as outlined

The panels tested were made of 24S-T aluminum-alloy sheet, and the general nature of the specimens is illustrated in Fig. 2. The test setup, with its paraphernalia of strain gages, etc., is shown in Fig. 3.

A set of 14 panel specimens was tested in compression to determine the effect of sheet curvature on the strain distribution around a circular hole in the sheet. Specimens with no reinforcement around the hole and specimens with doubler plate reinforcement of the hole were included. The radius of curvature of the sheet ranged from 10 in. to infinity. Identical specimens were tested with and without reinforcement in order to evaluate the effectiveness of the reinforcement.

Structural designers will not be satisfied until they have numerical values of the tests before them, but the formulas as above and the conclusions as below will already give them useful information.

"The tests indicate that, in the elastic region, the plane stress theory can be used to determine the median strain concentration and the shortening of the diameter to the hole in a cylindrically curved panel with an unreinforced circular hole. The theory will also reliably predict strains in the sheet outside the reinforcement in panels with doubler plate reinforced holes. If the reinforcements are attached with only one row of rivets, the strains in the reinforcement will be lower, and the strains in the sheet in the reinforced region higher, than those computed from the theory."

The paper on "A Numerical Procedure for the Stress Analysis of Stiffened Shells" by John E. Duberg (Langley Aeronautical Laboratory) was remarkable for two things. It was the first time that the problem of a stiffened shell in combined bending and torsion was considered in a publication. And it gave another example of the way in which numerical methods such as the iterative process are being widely applied in modern structural analysis. The author sets forth this problem very well. The ordinary engineering theories of stress analysis are used for the analysis of stiffened shell structures, and there are circumstances under which these theories can be considerably in error. A concentrated load applied to a stringer cannot be expected to be immediately distributed throughout the rest of the stringers, or, if stringers are interrupted by a cutout, some concentration of stress is expected in the neighborhood of the cutout. Other situations are the shell in flexure when one end is built into a rigid support, or there is a spanwise variation of cross-sectional properties or the distribution of shear along the length of the beam is not uniform. Under these circumstances the tendency of each cross section to warp out of its plane, which is necessary to establish the shear strains, is resisted by the rigid support or by the adjacent cross sections that want to warp differently and a change in stress distribution results. This problem has been recognized for some time and has become known as the shear lag problem. A similar situation exists in the case of the stiffened shell under torsion. If the shell is built in at one end or there is a variation in torque or cross-sectional properties along the length of the shell, the tendency of each cross section to warp is restrained and stresses are set up in the longitudinal directions. This problem also is well recognized, and the stresses induced have been called the bending stresses due to torsion.

These two problems, which are fundamentally similar have generally not been treated together in the literature because a more simple physical picture of the problem has sufficed for the torsion problem than for the bending problem. Most of the solutions available have been limited to boxes of rectangular cross section in which the cross-sectional properties are symmetrical about both the horizontal and vertical axes. The extension of these solutions to arbitrary cross sections has usually been too difficult to be of much practical use. The object of this paper was to establish a simple numerical method of stress analysis which requires but a single point of view to handle the bending and torsion problem of stiffened shells. The analysis is based on the same simplifying assumptions as are found in the previously developed theories in this field but is capable of ready application to unsymmetrical cross sections and multicelled boxes. The numerical process was set up so that at each step advantage could be taken of the process of continuous multiplication on an automatic calculating machine. The numerical problems actually solved are limited to the bending and torsion of single celled boxes of rectangular cross section. The method is general and can be applied to many other problems in stiffened shell analysis.

The quantities determined directly are the spanwise distributions of the axial displacements of the shell cross sections and the relative rotations and displacements of the shell cross sections. The numerical equations defining these qualities are solved by simple iteration. In order to obtain practical convergence of the process, it is necessary to refer displacements and loads to a set of axes in the cross section, which are defined as the principal axes for shear, and to resort to the occasional use of a special cycle in the iteration process, which in effect removes all displacements associated with planar distributions of axial displacement of the shell cross section. The details of the application of the procedure to a simple problem are shown in some detail, and the results obtained from a more complex problem are summarized.

Specifications for Transport Airplanes

Reflecting on the morning and afternoon Air Transport Sessions, it is curious that only two out of the seven papers dealt with equipment and the rest with navigation and control. Probably that is the right proportion. We have wonderful airplanes; the problem is to be able to fly them safely in all weathers. Still it is just as well to specify the best in cargo and passenger airplanes. Major R. R. Hajek (Military Air Transport Service) spoke on "Military Air Transport Service Specifications and Requirements for Cargo Aircraft." R. D. Kelly, R. L. McBrien, and Lester G. Kelso (United Air Lines) discussed "Evaluation Criteria for Transport Aircraft." Military air transportation has grown by leaps and bounds since World War II and has achieved wonders in strategic airlift, with the Berlin Airlift as the last and most magnificent example. Civil air transport has had an equal growth. It is scarcely remarkable that military and the civil experts came close together in their requirements. Both stressed: (1) ease of loading; (2) maintenance; (3) low cost of operation; (4) performance. The civil people talked more of safety, as one might expect, and of customer reaction. In neither paper could one find striking novelties; in both there was solid common sense.

Air Transport: Morning Session: *Chairman Knox McIlwain, Executive Vice-President, Eastern Region, Institute of Navigation; Ralph S. Damon, Former President of American Airlines, Inc. (now President of T.W.A.); J. H. Dellinger, Chairman of Radio Technical Commission for Aeronautics; and Douglas H. Ewing, Director of Development, Air Navigation Development Board.* **Air Transport—Afternoon Session:** *Chairman R. Dixon Speas, Assistant to Vice-President of Engineering, American Airlines, Inc.; Major R. R. Hajek, Chief of Aircraft Materiel and Equipment Branch, Division of Plans and Operations, M.A.T.S.; L. G. Kelso, United Airlines, Inc.; M. G. Beard, Director of Flight Engineering, American Airlines, Inc.; and W. E. Fensler, Chief, Special Projects Unit, Electronic Analysis Section, Intelligence Department, Air Materiel Command.*

The three civilians had a transport Aircraft Evaluation Check List that could serve operators the world over:

Operational Economics

- Type of service
- First cost (purchase price)
- Cost of introduction
- Route performance analysis
  - Direct flying cost
  - Break-even load factor
  - Indirect costs
  - Annual return on initial investment

Safety

- Procedural complexity
- System complexity
- Flight characteristics
- Detail design—including fire and crash survival

Performance

- Speeds
- Climb
- Airport

Weight and Balance

- C.g. movement permissible
- Pay load
  - Structure limited (zero fuel, floor loads)
  - Performance limited
  - Space limited
    - Passengers
    - Cargo
  - Range at maximum pay load

Comfort

- Air conditioning
- Sound level
- Vibration
- Rideability
- Interior illumination (including window size)
- Accommodations

Maintenance

- Detail design
- General accessibility
- Ground handling

Besides this Check List, Messrs. Kelly, McBrien, and Kelso discussed basic economic factors:

(*1*) *First Cost.*—Allow 20 per cent for spares and allow for cost of ground handling equipment.

(*2*) *Cost of Introducing a Fleet of New Airplanes.*—This has not been sufficiently analyzed and should be. To this disregarded cost factor are probably due some of the air lines' financial difficulties.

(*3*) *Route Analysis.*—The most important element in predicting the operating economy. For each route segment there must be made an analysis of the type shown in Table 1. Schedule of route segments depends on such a chart (Table 1).

(*4*) *Direct Operating Expense.*—This is not, as often thought, the predominant element in economic analysis of a line, except for routes having poor traffic potential.

(*5*) *Break-Even Load Factor.*—There are two ways of evaluating the Break-Even Load Factor. The first is

$$F_1 = (P_c/P_a)\ 100$$

where

F_1 = pay-load factor, per cent
P_c = pay-load actually carried, lbs.

TABLE 1

	Route Segment	Block Speed & Schedule Time	Pay Load, lbs.	Pay-Load Limiting Condition	Rev. P.O.T. Max. per Trip, $	Operating Cost per Trip Direct, $	Maximum Possible Pay-Load Factor, %	Break-Even Pay-Load Factor, % (Direct Flying Costs)	Margin Pay-Load Factor, %
1	LGA-CHI Alt.-MKE	225 m.p.h. 3.75 hours	7,400	Max. T. O. Weight	1,548	497	85.5	27.6	57.9
2	CHI-OMA Alt.-GRI	205 m.p.h. 2.09 hours	8,480	Max T. O. Weight	986	308	96.5	30.1	66.4
3	OMA-DEN Alt.-CYS	210 m.p.h. 2.33 hours	8,480	Max. T. O. Weight	1,120	312	96.5	26.9	69.6

P_a = pay-load carrying capacity utilizable, lbs.

The authors prefer a second concept:

$$F_2 = [P_c/(W_s - W_e)]\ 100$$

where

W_s = airplane gross weight, structurally limited for zero trip length, lbs.

W_e = airplane operating weight empty

The second concept is subtle but powerful.

Space permits the inclusion of but one additional topic discussed by the authors: "*Customer Reaction*" to ventilation, noise level, rideability, illumination, accommodations (safety understood). They forgot to mention one thing that newspapers and public have talked of recently: boredom. It is heresy but true to say that air passengers flying over land or sea are bored.

Navigation and Control in Air Transport

As we said previously, only two papers in the Air Transport Sessions dealt with equipment and all the others with Navigation and Control. Ralph S. Damon (formerly of American Airlines and now President of Transcontinental & Western Air) soon made it clear why such a disparity was justified when he spoke on "What the Air Lines Want in Navigation Aids." Without great advances in navigation and control, said Mr. Damon, the air lines would continue to suffer huge financial losses because irregularities and disruption of schedules by weather would drive passengers away from the airplane. The air lines, he continued, want a system that will enable them to fly every schedule without failure or delay due to weather. He described an ideal pattern under which a pilot could know where he was at all times and where other planes were on a large number of predetermined paths through the air. He hoped much from the omnidirectional range system now being constructed by C.A.A., but with this new system there was needed a traffic control system better adapted to the human limitations of the men who must operate the controls on the ground. Finally, the experienced executive said he wanted a cockpit system that, through the indications of simplified instruments, would enable the pilot to fly a course as easily as an automobile driver can be guided by the single white line in the middle of the highway.

Anyone who attended the Sessions in Instruments, Navigation and Control, and Human Engineering in Aviation would tell Mr. Damon that there is no lack of effort to make his wishes a reality.

What, for example, could benefit air-line operations more than "Air-Borne Radar in Air Transportation" as described by M. G. Beard and R. W. Ayer (American Airlines). It was a series of mountain crashes that led American Airlines to look into the AN/APS-10 radar equipment, originally designed toward the end of the war for the Army Air Forces Air Transport Command. This radar set was light weight, of low power output, and of short range, and it presented a maplike picture of terrain for a radius of about 10 miles round the aircraft. But that was the best that could be said for it. The authors describe its shortcomings graphically:

"When American Airlines first looked at this piece of equipment with the idea that perhaps the pilot himself could use it for warning of an impending collision with a mountain, we were sorely disappointed. Not only was the picture on the scope confusing, but, whenever the airplane banked, the picture was destroyed. The drag of the big bulge under the fuselage used to house the antenna was judged to be intolerable on a modern transport airplane. There was no place or opportunity to provide a radar operator in the modern domestic transport, yet one appeared to be required to examine the scope and interpret it. The equipment, according to civil standards, was heavy and unreliable and had a short range. The scope had to be viewed in near darkness; hence, it presented an almost insuperable problem for cockpit use. The controls were tricky and numerous and required too much manipulation, considering the present work-load of our flight crews. Perhaps most important of all, there seemed to be a peculiar prejudice among most pilots against the use of the equipment."

After thought and conferences between air-line and electronic engineers, it was agreed that to secure for the pilot effective warning of an approaching mountain collision, there was needed a minimum simplified presentation that "would confine its searching to a horizontal plane, eliminating other downward vision much as the driver of a tank looks through his slit; and if the information could be presented to the pilot in the form of a polar coordinate plot giving true azimuth and distance directly, then we would have something the pilot

could use directly without the need for much interpretation." After much cut-and-try experimentation to realize this ideal, first in a Converted C-47 and then in a Convair, the flight research personnel of American achieved success. They could fly blind below the level of hilltops with ease and security using the radar alone. They found that thunderstorms could be not only avoided but negotiated, most dangerous icing conditions could be avoided, and the soft spots in deep fronts could be found with ease. Using radar beacons or responders placed upon the ground at each end of a landing runway, they found that simple and precise instrument approaches to a landing runway could be made, precise approach-area and cross-country navigation was available, and a method of presenting information to the pilot had been discovered which was superior to the usual system of dials and gages. Research is continuing, using the Convair Flagship Gamma, which has a flight station in the cabin. It seeks first, a method of detecting the location of hail in thunderstorms; second, a method for distinguishing between the radar echoes produced by rain and those produced by hills; and third, the exact location of the dangerous turbulence within a thunderstorm. Also, they contemplate tests for the precision with which a pilot can fly a required track using radar beacons.

What would encourage Mr. Damon still more is that there is really a national program under way with governmental bodies cooperating on "The Common System of Air Navigation and Traffic Control." J. H. Dellinger (Radio Technical Commission for Aeronautics) spoke of a "Transition Program"; Douglas H. Ewing (Air Navigation Development Board) talked of an "Ultimate Program." The whole constitutes an ambitious, thoroughly sound plan. The program is in two stages. First, a transition period of about 5 years will utilize improved devices already developed as fast as the improved equipment can be delivered in quantity and put in operation. Second, the ultimate system, to be in operation by 1963. It will make use of such advances as radar, television, and electronic computing machines. How can one undertake a 15-year program without freezing progress? The question is kept in constant view, and the program has the very objective of stimulating progress. The following facilities will be completed within the 5-year transition program:

(1) Omnirange stations, providing a multitude of courses radiating like the spokes of a wheel.

(2) Distance-measuring equipment, associated with omnirange stations, to provide aircraft with measurement of distance to the station continuously.

(3) A simple automatic computer (on the aircraft), for use with both of these to provide courses between other points.

(4) Instrument landing systems (ILS).

(5) Precision beam radar, similar to GCA, to complement and monitor the ILS fixed-path approach system.

(6) Some radar surveillance to assist traffic control.

(7) Improved approach and runway lighting.

During the transition period preparations for the ultimate program will proceed actively.

"A Simplified Monitoring System for Air-Borne Electronic Devices" by W. E. Fensler (Air Materiel Command). The author described a German system of simplified testing and replacement-maintenance. This system is predicated upon two ideas: (1) self-contained circuitry to permit rapid and easy isolation of faults; and (2) a simplified method of fault correction.

The German approach to fault isolation features the provision of built-in test meters and signal generators, the inclusion of multipoint jacks for use with standard plug-in test meters and small portable signal generators. The electronics equipment was constructed of as many plug-in units as feasible. Thus, personnel unskilled in electronics maintenance could ascertain with accuracy the operating condition of equipment, could isolate faults, and could replace faulty components either on the ground or in flight. Fewer spares, less elaborate test equipment, and fewer repair men were needed than was common with similar equipment used by the Allies.

Psychologists to the Rescue

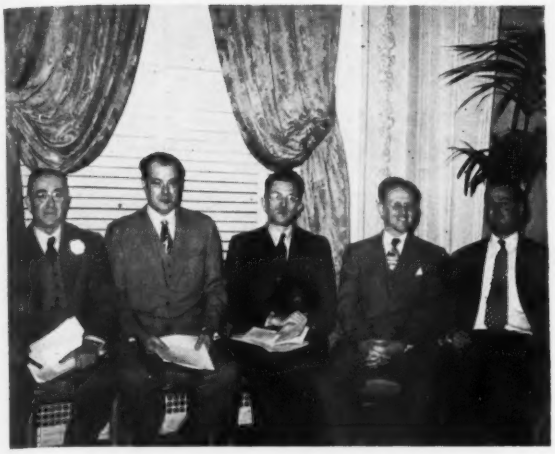
From the long gone day when Bessemer invented his steel-making furnace to last year or so when Norbert Wiener invented "cybernetics" and explained the functioning of the human brain by a combination of Laplace Transform, the theory of servomechanisms, and electronic circuits, the most fruitful field of scientific and technical advance has been at the juncture of two or more fields of knowledge. Here is another example, the combination of aviation and psychology, as presented in a Session called Human Engineering. It was most appropriate that Dr. Ross A. McFarland, of Harvard University, with his vast studies in aviation fatigue, should have, in another luncheon talk, introduced the Session on Human Engineering and given its keynote. Dr. McFarland pleaded for a more objective analysis of pilot capabilities, cited occasions where the faulty design of cockpit controls had caused accidents, and urged that physiologists and psychologists examine the design of all future transport aircraft before they were put into production. Every man who spoke in the Human Engineering Session was a psychologist, and every paper presented in this Session strengthened Dr. McFarland's argument, directly or indirectly.

For example, Dr. Paul M. Fitts (Wright-Patterson Air Force Base) spoke on "Eye Movements of Aircraft Pilots During Instrument Flights" and thereby gave lessons to the designer of instruments, of cockpit installations, of the plane as a whole. Dr. Fitts used a 35-mm. movie camera to photograph reflections of pilots' eyes while flying a C-45 cargo aircraft in precision maneuvers, including blind landings. Here is, in part, his own summary of his results: "Data were analyzed in reference to maneuvers, experience level, and individual differences. For the instrument panel and aircraft used, average fixation times for different instruments

Human
Professo
Commit
P. J. K
Associa
C. P. S
Special
Profess

during
sec. p
ments
92 pe
most
right-
left t
ments
in rea
are fu
cision
Noth
cumu
strun
panel

In
medi
speal
perh
Asht
cine)
of D
migh
"Th
orien
othe
pose
the
supe
cues
The
to w
forc
not
are
into



Human Engineering in Aviation: *Chairman Morris S. Viteles, Professor of Psychology, University of Pennsylvania, and Chairman, Committee on Aviation Psychology, National Research Council; P. J. Rulon, Educational Research Corporation; M. G. Preston, Associate Professor of Psychology, University of Pennsylvania; C. P. Seitz, Head, Research Section, Human Engineering Branch, Special Devices Center; and A. C. Williams, Jr., Research Assistant Professor of Psychology, University of Illinois.*

during an ILS landing approach varied from 0.3 to 0.9 sec. per fixation; different flight and engine instruments were 'looked at' from 1 to 30 times per min.; 92 per cent of all fixations were on four instruments; most eye movements were in the horizontal plane; right-left movements occurred as often as those from left to right. Average eye fixations on aircraft instruments are from two to three times as long as fixations in reading. It appears that eye movement patterns are functions of difficulty of interpretation, reading precision necessary, and importance of the displayed data." Nothing could be a sounder guide than the data accumulated by Dr. Fitts for the design of aircraft instruments and for their location on the instrument panel.

In detective stories it is customary to poke fun at medical witnesses who use ultratechnical language in speaking to the jury. Perhaps it cannot be helped, and perhaps there is excuse for the phraseology that Captain Ashton Graybiel (U.S. Naval School of Aviation Medicine) employed in his paper on "Some Important Causes of Disorientation in Pilots," in that engineering laymen might not otherwise pay attention to the medical man. "The pilot is faced with the necessity of being properly oriented to the plane, to the earth, and possibly to other objects as well. Orientation to the plane rarely poses difficulties, because cues are provided by the eyes, the labyrinth, and the sensory elements concerned with superficial and deep sensibility. Of all these, only visual cues can be relied upon for orientation to the earth. The others are misleading whenever the resultant force to which the flier is subject differs in direction from the force of gravity. Hence, orientation to the plane cannot safely be used for orientation to the earth." We are strongly tempted to translate this last quotation into "A pilot cannot fly by the seat of his pants." But language apart, there is good stuff in the paper. The author makes a good plea for instrument flying, even when the pilot can fly contact. "The sole reliance on visual cues is not without its limitations and hazards. Thus, even under favorable circumstances, vision requires the considerable attention of the pilot, and, if the altitude of the plane is rapidly changing, the attention must be almost continuous. Moreover, under these conditions, visual orientation to the earth may be difficult because of conflicting cues, and the pilot may be subject to visual illusions, especially at night." There are parts of the ear other than those concerned with hearing which cause trouble. "Of particular interest in this connection is the role played by those portions of the labyrinth which are not concerned with hearing—namely, the semicircular canals and the otolith organs. The effects of stimulation can be readily demonstrated and studied in the laboratory. From observations carried out both in the laboratory and during actual flight, it is concluded that another important factor in causing disorientation in flight is the effect of radial and linear accelerations on the otolith organs, even though the response is normal."

It is remarkable how widespread is the use of psychological measurement in aviation problems and how closely the psychologist's methods come to those of the engineer. Thus, Professor Thomas Gordon (University of Chicago) in "The Establishment and Measurement of Critical Requirements for Safe Flight in Transport Aircraft" defined the psychologist's methods as follows: "The psychologist's methods of developing an objective and reliable procedure for measuring pilot proficiency are compared with the methods used by an engineer in developing an improved instrument for measuring altitude. A research program to develop an objective flight check for evaluating pilots is described, and some of the results are reported. The project has yielded an evaluation procedure that is objective, easy to administer, and reliable. The measuring instrument is based upon empirically determined critical requirements of the pilot's job."

It will be remembered that Dr. Dellinger considered the omnidirectional range system (VOR) a vital element of his 5-year transition program. It is all the more important that this new device (which gives the pilot continuous accurate visual information concerning his bearing to or from any selected VOR station, making it possible to fly to a station along any desired course or from any station in any desired direction) should be as convenient to the pilot as possible. To this end two other psychologists, A. C. Williams, Jr., and Stanley Roscoe (University of Illinois) studied "Display Problems in the Use of the Omnidirectional Range Instrument." The authors were not concerned with engineering criteria but with the speed and accuracy with which representative pilots could use various VOR displays for navigation. They used mock-ups of the displays rather than actual flight instruments, which were pro-

(*Continued on page 87*)

I.A.S. Preprints

Preprints of Seventeenth Annual Meeting Papers Currently Available

No.

171 Preliminary Development of a Jet-Propelled Helicopter—Roy E. Marquardt, President, Marquardt Aircraft Company.

172 The McDonnell Ram-Jet Helicopter—Charles R. Wood, Jr., Chief Helicopter Test Pilot and Manager, Helicopter Contracts, McDonnell Aircraft Corporation.

173 A Method for Improving the Inherent Stability and Control Characteristics of Helicopters—R. H. Miller, Associate Professor of Aeronautical Engineering, M.I.T.

174 Recent Developments in Rotary-Wing Aircraft—I. I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation.

175 The Pfund Sky Compass—Joseph B. Matthews, Jr., Head Navigation Branch, Airborne Equipment Division, Bureau of Aeronautics, Navy Department.

176 A Liquid Oxygen Converter for Aircraft—W. A. Wildhack, Chief, Missile Instrumentation Section, Electronics Division, and D. S. Goalwin, National Bureau of Standards.

177 A New High Performance Engine Indicator of the Strain Gage Type—C. S. Draper, Professor of Aeronautical Engineering, Director of Instrumentation Laboratory, and Y. T. Li, Research Associate in Aeronautical Engineering, M.I.T.

178 The Sperry Zero Reader—S. Kellogg, Engineering Department Head for Flight Instruments, and C. F. Fragola, Engineering Section Head for Electronic Development, Sperry Gyroscope Company.

179 Convertible Aircraft—R. S. Barnaby, Chief, S. M. Berkowitz, Project Leader, and W. H. Colcord, Assistant Chief, Aeronautics Section, The Franklin Institute.

180 Present Status of Research on Boundary-Layer Control—A. E. von Doenhoff and L. K. Loftin, Full Scale Research Division, Langley Aeronautical Laboratory, N.A.C.A.

181 Measurements in Flight of Spanwise Wing Loading—W. Lavern Howland, Flight Service Engineering Supervisor, Lockheed Aircraft Corporation.

183 Aerodynamic Hysteresis as a Factor in Critical Flutter Speed of Compressor Blades at Stalling Conditions—A. Mendelson, Lewis Flight Propulsion Laboratory, N.A.C.A.

184 Designing for Gas Turbine Materials—M. H. Young, Chief, Materials Laboratory, Wright Aeronautical Corporation.

186 Influence of Acceleration on Aerodynamic Characteristics of Thin Wings in Supersonic and Transonic Flight—C. S. Gardner, Research Associate, and H. F. Ludloff, Associate Professor, New York University.

187 Dynamic Stability at High Speeds from Unsteady Flow Theory—I. C. Statler, Aerodynamicist, Flight Research Department, Cornell Aeronautical Laboratory.

188 The Problem of Drag at High Subsonic Speeds—A. Busemann, Compressibility Research Division, Langley Aeronautical Laboratory, N.A.C.A.

190 Two-Dimensional Jet Mixing of a Compressible Fluid—S. I. Pai, Cornell Aeronautical Laboratory.

No.

191 Interaction Between Parallel Streams of Subsonic and Supersonic Velocities—H. S. Tsien, Professor of Aerodynamics, and M. Finston, Staff Member, Supersonic Laboratories, Division of Industrial Cooperation, M.I.T.

194 A Study of the Bending-Torsion Aeroelastic Modes for Aircraft Wings—Martin Goland, Chairman, Engineering Mechanics Division, and Yudell L. Luke, Research Mathematician, Midwest Research Institute.

196 Landing Gear Oscillations Due to Unstable Skidding Friction—J. E. Wignot, Structures Engineer, and Frederic M. Hoblit, Stress Engineer, Lockheed Aircraft Corporation.

197 A New Approach to the Design of Metering Pins in Oleo Struts—R. M. Rosenberg, Associate Professor of Aeronautical Engineering, University of Washington.

198 Compression Tests of Curved Panels with Circular Hole Reinforced with Circular Doubler Plates—Wilhelmina D. Kroll, Aeronautical Engineer, A. E. McPherson, Materials Engineer, Engineering Mechanics Section, National Bureau of Standards.

199 A Numerical Procedure for the Stress Analysis of Stiffened Shells—John E. Duberg, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A.

200 Theories of Plastic Buckling—S. B. Batdorf, Structures Research Division, Langley Aeronautical Laboratory, N.A.C.A.

201 Theory and Tests on the Plastic Stability of Plates and Shells—P. P. Bijlaard, Professor of Applied Mechanics, Polytechnic Institute of Delft, Holland.

204 What the Air Lines Want in Navigation Aids—Ralph S. Damon, President, American Airlines, Inc. Now, President, T.W.A.

205 Military Air Transport Service Specifications and Requirements for Cargo Aircraft—Major R. R. Hajek, Chief of Aircraft Materiel and Equipment Branch, Division of Plans and Operations, M.A.T.S.

206 Evaluation Criteria for Transport Aircraft—L. G. Kelso, R. L. McBrien, Technical Staff, and R. D. Kelly, Superintendent of Technical Development, United Air Lines, Inc.

207 Air-Borne Radar as an Air-Line Navigation Aid—M. G. Beard, Director of Flight Engineering, and R. W. Ayer, Assistant Director of Flight Engineering, American Airlines, Inc.

208 A Simplified Monitoring System for Air-Borne Electronic Devices—W. E. Fensler, Chief, Special Projects Unit, Electronic Analysis Section, Intelligence Department, Air Materiel Command.

209 Psychological Factors in the Recognition and Avoidance of the Inadvertent Stall—P. J. Rulon, Educational Research Corporation.

210 The Establishment and Measurement of Critical Requirements for Safe Flight in Transport Aircraft—Thomas Gordon, Assistant Professor of Psychology, University of Chicago.

211 The Research Program of the Special Devices Center, ONR, on Human Problems in Flying—Clifford P. Seitz, Human Engineering Branch, Special Devices Center.

212 Display Problems in the Use of the Omni-Directional Range Instrument—A. C. Williams, Jr., Research Assistant Professor of Psychology, and Stanley Roscoe, University of Illinois.

213 Eye Movements of Aircraft Pilots During Instrument-Landing Approaches—Paul M. Fitts, Aero Medical Laboratory, Wright-Patterson Air Force Base.

(Preprints of papers listed above are 35 cents each to I.A.S. members, 75 cents each to nonmembers including postage.)

Preprints should be ordered by number from:

Preprint Department, Institute of the Aeronautical Sciences
2 East 64th St., New York 21, N.Y.

SPECIAL I.A.S. PUBLICATIONS

Sherman M. Fairchild Publication Fund Papers

No.		Price
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, G. L. Pigman, Civil Aeronautics Administration. 52 pages; 23 illus. (Photo-offset.)	$1.00*
100	Blade Pitching Moments of a Two-Bladed Rotor—R. W. Allen, Consulting Engineer. 19 pages; 5 illus. (Ozalid.)	$1.00*
101	Introduction to Shock Wave Theory—J. G. Coffin, Kaiser Fleetwings, Inc. 106 pages; 33 work tables & charts. (July, 1947, p. 28.)† (Ozalid.)	$3.50*
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist, Department of Engineering, State University of Iowa. 15 pages; 7 illus. (Ozalid.)	$0.80*
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr., Research Engineer, Grumman Aircraft Engineering Corporation. 66 pages; 6 illus. (April, 1947, p. 28.)† (Ozalid.)	$2.50*
105	An Evaluation of the Importance of Fatigue Phenomena in Aircraft—C. R. Strang, L. R. Jackson, L. F. McBrearty, R. V. Rhode, and R. L. Schleicher (A Round-Table Discussion). 34 pages; no illus. (Mimeographed.)	$1.10*
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland, Lockheed Aircraft Corporation. 13 pages; 5 illus. (Ozalid.)	$0.50*
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley, Massachusetts Institute of Technology. 88-page booklet; 28 tables & figures. (Photo-offset.)	$1.50*
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium). 100-page booklet; 45 illustrations. (Photo-offset.)	$2.50*
166	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology. 68-page booklet; 14 illustrations. (Photo-offset and Multilith.)	$1.60*
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology. 36-page booklet; 13 illustrations. (Photo-offset and Multilith.)	$1.00*
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology. 54-page booklet; 38 illustrations. (Photo-offset and Multilith.)	$1.60*
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology. 42-page booklet; 5 illustrations. (Multilith.)	$1.00*
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology. 52-page booklet; 39 illustrations. (Multilith.)	$1.60*

* A 25% discount on these prices is allowed to Institute members. † Indicates issue of Review in which summary of paper appears.

Now Available

1948 Aeronautical Engineering Index

A complete index and abstracts of the more than 5,000 important technical articles, reports, and books on aeronautics published during the calendar year 1948

Price $5.00 ($3.00 to I.A.S. members *only*)

(For further information and Coupon Order Form, see page 69)

Published by

Institute of the Aeronautical Sciences

2 E. 64th St., New York 21, N.Y.

EATON

Zero-Lash

Registered U. S. Patent Office

HYDRAULIC VALVE LIFTERS

The Modern Method of Valve Actuation

Millions of Zero-Lash Hydraulic Valve Lifters and Zero-Lash adjusting units—designed and developed exclusively by Eaton Manufacturing Company—have gone into leading automotive, aircraft, tractor, marine and industrial engines in the last 17 years. They have contributed:

- **Freedom from Tappet Adjustments for the Life of the Engine.**
- **Accurate Valve Timing and Perfect Seating at All Engine Speeds and Temperatures.**
- **Longer Life for Valves and Seats.**
- **Silent Valve Train Operation.**

Since 1932 Eaton Engineering Departments have been engaged in constant research and development of improved designs and of new wear-resistant materials which make today's—and tomorrow's—Zero-Lash Hydraulic Valve Lifters the truly modern method of valve actuation.

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

Saginaw Division

9771 French Road · Detroit 13, Michigan

PRODUCTS: SODIUM COOLED, POPPET, AND FREE VALVES • TAPPETS • HYDRAULIC VALVE LIFTERS • VALVE SEAT INSERTS • ROTOR PUMPS • MOTOR TRUCK AXLES • PERMANENT MOLD GRAY IRON CASTINGS • HEATER-DEFROSTER UNITS • SNAP RINGS • SPRINGTITES SPRING WASHERS • COLD DRAWN STEEL • STAMPINGS • LEAF AND COIL SPRINGS • DYNAMATIC DRIVES, BRAKES, DYNAMOMETERS

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

The abstracts are classified according to the Standard Aeronautical Indexing System. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement. Headings marked by an asterisk have not yet been established by the S.A.I.S.

Aerodynamics (2)
- Aerodynamic Loads ... 50
- Boundary Layer ... 50
- Control Surfaces ... 50
- Fluid Mechanics & Aerodynamic Theory ... 50
- Internal Flow ... 52
- Parasitic Components & Interference ... 54
- Stability & Control ... 54
- Thermo-Aerodynamics ... 56
- Wings & Airfoils ... 56

Air Transportation (41) ... 58
Airplane Design & Description (10) ... 58
Airports & Airways (39) ... 60
Atomic Energy (48) ... 60
Aviation Medicine (19) ... 60
Comfortization (23) ... 62
Education & Training (38) ... 62
Electronics (3) ... 62
Engineering Practices (49) ... 66
Equipment ... 66
- Electrical (16) ... 66
- Hydraulic & Pneumatic (20) ... 68

Flight Operating Problems (31)
- Climatization ... 68
- Ice Prevention & Removal ... 68
- Piloting Technique ... 68

Flight Safety & Rescue (15) ... 68
Fuels & Lubricants (12) ... 68
Gliders (35) ... 68
Guided Missiles (1) ... 70
Instruments, Aircraft (9) ... 70
Lighter-Than-Air (40) ... 70
Machine Elements (14) ... 72
Maintenance (25) ... 72
Management & Finance (45) ... 72
Materials (8)
- Metals & Alloys ... 72
- Nonmetallic Materials ... 74
- Sandwich Materials ... 74

Meteorology (30) ... 74
Military Aviation (24) ... 75
Navigation (29) ... 75
Photography (26) ... 75
Power Plants ... 75
- Jet & Turbine (5) ... 75
- Reciprocating (6) ... 78
- Rocket (4) ... 78

Production (36) ... 78
Propellers (11) ... 80
Reference Literature (47)
- Bibliographies ... 80

Rotating Wing Aircraft (34) ... 82
Sciences, General (33)
- Mathematics ... 82
- Mechanics ... 82

Structures (7) ... 82
Thermodynamics (18) ... 86
Water-Borne Aircraft (21) ... 86
Wind Tunnels (17) ... 87

II. BOOKS REVIEWED IN THIS ISSUE

Mechanics. J. P. Den Hartog ... 89
Reviewed by F. R. Shanley, The Rand Corporation

Supersonic Flow and Shock Waves. R. Courant and K. O. Friedrichs ... 91
Reviewed by Prof. H. W. Liepmann, California Institute of Technology

Airport Management. John H. Frederick ... 93
Reviewed by Charles Froesch, Eastern Air Lines, Inc.

Combustion Engines. Arthur P. Fraas ... 93
Reviewed by P. B. Taylor, Sanderson & Porter

Mechanical Vibrations. W. T. Thomson ... 94
Reviewed by Dr. C. T. Wang, New York University

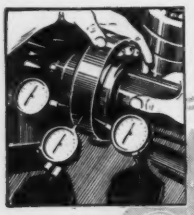
Book Notes ... 94

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not Members of the Institute may borrow books and, in special cases, other research material. Members of the I.A.S. may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.25 for each 8- by 10-in. print and $0.30 for each 10- by 14-in. print, plus postage. *Microfilm copies* on 35-mm. film can be supplied at $0.05 per frame; minimum charge—$1.00, plus postage. A service charge of $0.50 per item on photostat and microfilm orders is made to nonmembers of the I.A.S.

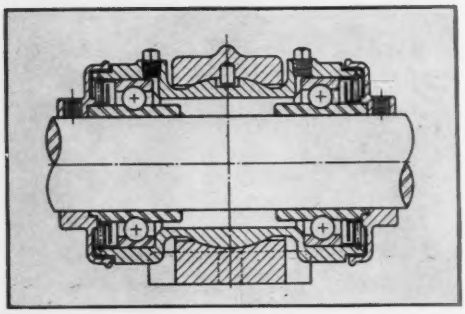
Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. I.A.S. members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.



with BALL BEARINGS

— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished mechanism.



with TRACING CLOTH . . .

The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Through continued research and development plus skilled manufacturing processes, Arkwright Tracing Cloths meet every requirement of exacting draftsmanship. You'll find no pinholes, stains or other imperfections to detract from drawing quality — nor smudging or feathering after repeated erasures. Most of all, you'll have highly transparent, long lasting usefulness that perishable tracing paper can never match.

For every drawing worth keeping for future use — specify permanent Arkwright Tracing Cloth. Send now for generous working samples. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

ARKWRIGHT

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 25 YEARS

Aerodynamics (2)

AERODYNAMIC LOADS

An Analysis of the Airspeeds and Normal Accelerations of Douglas DC-2 Airplanes in Commercial Transport Operation. Walter G. Walker. *U.S., N.A.C.A., Technical Note No. 1754,* November, 1948. 14 pp., figs. 10 references.

Analysis of acceleration and air-speed data obtained from 33 V-g records taken on DC-2 airplanes during operations along the East Coast of the U.S. indicates that the design maximum level-flight speed would be exceeded on the average of once in about 7.3×10^5 flight miles and that the limit gust load factor would be exceeded on the average of once in about 1.5×10^8 flight miles. The DC-2 airplane flight loads and the route roughness encountered over the East Coast appear to be small when compared with the data obtained for the other routes analyzed.

BOUNDARY LAYER

The Laminar Boundary Layer. N. A. V. Piercy, L. G. Whitehead, and R. A. Tyler. *Aircraft Engineering,* Vol. 20, No. 238, December, 1948, pp. 354–359, figs. 9 references.

A series solution of the equations for steady two-dimensional flow in a boundary layer is obtained for cylinders with a rounded nose. When the flow is symmetrical, the range of the solution is wider than that encompassed by the methods of both Howarth and Falkner. An approximate solution is developed from the series solution which may be used when the convergence of the series becomes poor and which, when used throughout the entire problem, eliminates the restriction of a rounded nose. General expressions for the skin friction, the velocity, and the momentum and displacement thickness are given in terms of two parameters that may be readily evaluated from a pair of first order differential equations. For Schubauer's elliptic cylinder and for a case of retarded flow, the methods give results comparable in accuracy to Hartree's calculations, except in the immediate vicinity of the breakaway point of the boundary layer. The approximate solution is in a form that is applicable to a wide variety of boundary-layer problems. It can also be greatly simplified for those cases in which an additional small error is tolerable.

Skin Friction in the Laminar Boundary Layer in Compressible Flow. A. D. Young. *College of Aeronautics, Cranfield, England, Report No. 20,* July, 1948. 31 pp., figs. 15 references.

From an analysis of the work of Crocco, semiempirical formulas are derived for the skin friction on a flat plate at zero incidence with a laminar boundary layer, for the general case of heat transfer, and for the case in which there is no heat transfer. These equations account for dissipation and the effects of radiation. The formula for the case involving no heat transfer is used to develop an approximate method for solving the momentum equation of the boundary layer on a cylinder without heat transfer. This method shows that when there is a constant adverse velocity gradient of a flat plate, there is a marked forward movement of separation of the boundary layer as the Mach Number increases.

CONTROL SURFACES

Theoretical Forces and Moments on a Thin Aerofoil with Hinged Flap at Supersonic Speeds. A. R. Collar. *Gt. Brit., Aeronautical Research Committee, Reports and Memoranda No. 2004,* November, 1943. 6 pp., figs. 3 references. British Information Services, New York. $0.45.

The application of Ackeret's theory shows that the theoretical values of the coefficients of an airfoil with plain hinged flap have the same signs and are of the same order of magnitude at supersonic speeds as at subsonic speeds. They are, however, functions of the Mach Number and decrease with increasing speed.

FLUID MECHANICS & AERODYNAMIC THEORY

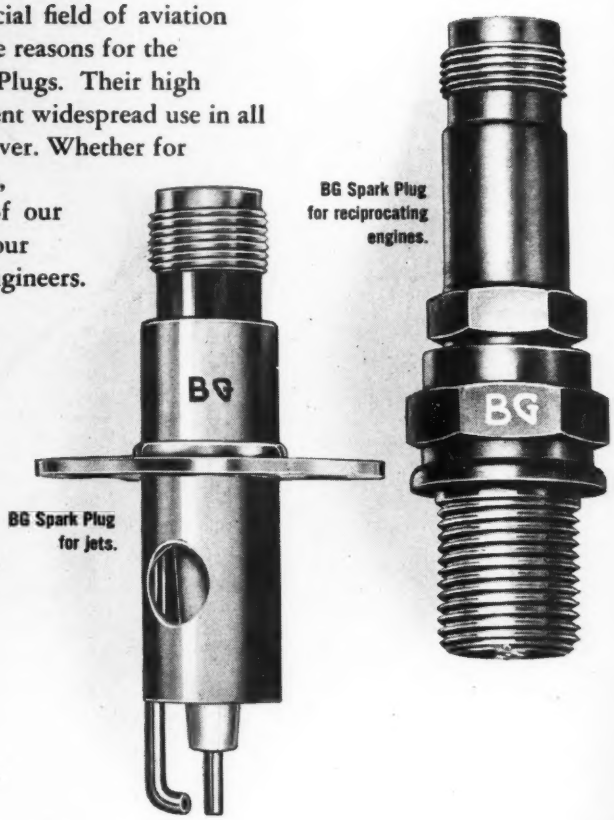
Methods for Predicting Phenomena in the High-Speed Flow of Gases. M. J. Lighthill. *Journal of the Aeronautical Sciences,* Vol. 16, No. 2, February, 1949, pp. 69–83, figs. 96 references.

A synopsis of compressible fluid dynamics which treats the foundations of the subject, boundary layer, isentropic flow, plane waves, and the differences between steady subsonic and supersonic flow; the perturbation methods of solution, including the linearized theory of supersonic flow in its many ramifications, which is compared with more exact work that has been done in

BG

Symbol of Dependable Service Since 1917

Long experience in the special field of aviation ignition is one of the notable reasons for the dependability of BG Spark Plugs. Their high quality has led to their present widespread use in all types of aircraft the world over. Whether for reciprocating or jet engines, —you may avail yourself of our experience by discussing your particular needs with BG engineers.



FOR AIRCRAFT ENGINES...
AIRCRAFT SPARK PLUGS

THE BG CORPORATION

NEW YORK 19, N.Y.

special cases; an outline of the theory of characteristics; and a full discussion of the uses of the hodograph transformation.

Preliminary Tests on Electric Potential Flow Apparatus. F. Cheers, W. G. Raymer, and R. G. Fowler. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2205*, November, 1945. 5 pp., illus., diagrs., figs. 4 references. British Information Services, New York. $0.45.

Coincidence of potential flows in an electrolytic with those in an aerodynamic field. A wax model is formed in a shallow, rectangular basin, 1 by 2 m., with sides sloping 5° to the horizontal. The tank has a plate glass lining with a slab of slate beneath and is surrounded by a wooden frame reinforced with metal and mounted on a strong table, which is fixed to the floor. A sheet of graph paper placed between the glass and the slate facilitates the location of model and waterline. Measurements of the potential gradient at points in the tank are used to obtain the velocity in the corresponding aerodynamic field. Tests in the tank without and with a model obtain a difference between theoretical and experimental values of less than a reducible 1.5 per cent. Tests should give a good picture of the potential flow past bodies that cannot be treated theoretically.

Applications of the Theory of Free Molecule Flow to Aeronautics. Holt Ashley. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, pp. 95–104, figs. 9 references. (Cf. AER 1/49:49.)

The Oscillating Wedge in a Supersonic Stream. G. F. Carrier. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, pp. 150–152, fig. 2 references.

The theory of an oscillating airfoil in a supersonic stream is modified by taking into account the presence of a shock and the acoustic waves that are reflected from it. The perturbation wave functions for a wedge of finite chord and infinite span, which execute small oscillations about its leading edge, are determined in a conventional product-series expansion, and the recurrence formulas for the associated coefficients are obtained. A comparison with the no-shock case shows that the weak-shock solution is not appreciably altered by the omission of the shock boundary conditions but that the omission makes an appreciable change in the solution for a strong shock.

Decay of Turbulence in the Final Period. G. K. Batchelor and A. A. Townsend. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 194, No. 1039, November 9, 1948, pp. 527–543, figs. 10 references.

The final period of decay of a turbulent motion occurs when the effects of inertia forces are negligible. Under these conditions the instantaneous velocity distribution in the turbulence field may be solved as an initial value problem. Homogeneous turbulence tends to an asymptotic statistical state that is independent of the initial conditions. In this asymptotic state the energy of turbulence is proportional to $t^{-5/2}$ and the longitudinal double-velocity correlation coefficient for two points distance r apart is $e^{-r^2/6t^2}$, where t is the time of decay. The asymptotic time-interva correlation coefficient is found to be different from unity for extremely large time intervals only, showing the aperiodic character of the motion. The whole field of motion comes gradually to rest, smaller eddies decaying more rapidly than larger eddies, and the above stable eddy distribution s established when only the largest eddies of the original turbulence remain. Relevant measurements were made in the field of isotropic turbulence downstream from a grid of small mesh. The above energy decay and space-interval correlation relations are valid at distances from the grid greater than 400-mesh lengths and at a mesh Reynolds Number of 650. The duration of the transitional period, in which the energy decay law is changing from that appropriate to the initial period of decay to the above asymptotic law, increases rapidly with R_M. Clarification of the criterion for the existence of final period decay must wait until the existence and termination of the initial period of decay are better understood.

Readers' Forum: Aerodynamic Relations With Variable Specific Heat. J. D. Schetzer. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, pp. 190, 191, figs.

Correction factors that must be applied to the equations for the pressure, density, and temperature ratios across normal shock waves at Mach Numbers from 0 through 6 when the basic equations assume that the ratio of specific heats for air is a constant, 1.4.

Readers' Forum: Impact Tube at Low Pressure—Errata. Paul L. Chambré. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, p. 190.

Drag Coefficients of Steel Spheres Entering Water Vertically. Albert May and Jean C. Woodhull. *Journal of Applied Physics*, Vol. 19, No. 12, December, 1948, pp. 1109–1121, figs. 3 references.

Readers' Forum: On the Hodograph Method. Y. H. Kuo. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, p. 189. 5 references.

A comparison of the Lighthill-Cherry and the Tsien-Kuo methods of obtaining an analytic continuation of a Taylor series in order to obtain a complete solution, using the hodograph method, of the transonic flow of a compressible fluid about a closed cylinder.

Interpreting Supersonic Literature. Howard Westgate. *Nebraska Blue Print*, Vol. 48, No. 2, November, 1948, pp. 29, 34, 40, 44, 48, figs. Definition of the shock wave and its relation to altitude.

Waves in Compressible Media. I—Basic Equations. II—Plane Continuous Waves. W. Weibull. (*Kungliga Tekniska Högskola, Handlingar Nr. 18*, 1948.) *Acta Polytechnica* (Stockholm), No. 26 (*Physics and Applied Mathematics Series*, Vol. 1, No. 5), 1948. 38 pp., figs. Sw. Kr. 3.

Formulas for the propagation of pressure waves in various media are developed from the basic equations for the conservation of mass, energy, and momentum, and the equations of state for stressed and unstressed solids, liquids, and gases. In the continuous portion of the wave, isentropic conditions are assumed; hence, the entropy of an individual element of mass is considered to be constant except at the instant when it crosses a surface discontinuity—i.e., a shock-wave front. The general properties and boundary conditions are developed for waves in which the particle velocity and the propagation velocity, a function of the pressure, are additive and for waves in which the particle velocity is subtracted from the wave-propagation velocity. These formulas are used to investigate changes in the wave form, superposition, and the reflection of plane continuous waves of finite amplitude. Tables give the properties of air of moderate density and the characteristics of shock waves in air for temperatures from 273.16° to 4,000°K.

INTERNAL FLOW

Some Effects of Compressibility on the Flow Through Fans and Turbines. W. Perl and H. T. Epstein. *U.S., N.A.C.A., Report No. 842*, 1946. 7 pp., figs. 1 reference. U.S. Govt. Printing Office, Washington. $0.15.

The laws of conservation of mass, momentum, and energy, when applied to compressible flow through a two-dimensional cascade of airfoils, show a fundamental relation between the ultimate upstream and downstream flow angles, the inlet Mach Number, and the pressure ratio across the cascade. Two ranges of flow angles and inlet Mach Numbers exist for which there is no ideal pressure ratio. One of these ranges is analogous to a similar type of incompressible flow. The other is characteristic only of compressible flow. In certain ranges of the flow angles, two possible pressure ratios are predicted for a given inlet Mach Number and flow angle. The analysis can also take into account the effect of a variable axial-flow area.

The Analytical Design of an Axially Symmetric Laval Nozzle for a Parallel and Uniform Jet. Kuno Foelsch. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, pp. 161–166, 188, figs. 6 references.

The equations for the contours of a three-dimensional nozzle with axial symmetry and for any stream line in the nozzle's flow are derived by integrating the characteristic equations for the axially symmetric flow. Since these equations cannot be integrated in exact form, an approximation is made by considering the flow in the nozzle to approach that in a cone. A factor f is introduced which remains undetermined and is not involved in the final equation and which expresses the relation between the direction and the velocity of the flow along a certain Mach line in the region where the flow from the conical source is converted into a parallel stream of uniform velocity. The spherical sonic-flow section is converted into a plane circular section of the throat. The contour adjacent to the throat is formed by the arc of a circle connected with the transition curve by a straight line. The gas dynamic properties of the boundary Mach line are tabulated to shorten the calculations.

Two-Dimensional Compressible Flow in Conical Mixed-Flow Compressors. John D. Stanitz. *U.S., N.A.C.A., Technical Note No. 1744*, November, 1948. 75 pp., figs. 10 references.

Even the pilot has to be told when he's on the ground

WHEN the wheels of the 92-ton Constitution—world's biggest passenger plane—touch the runway, it's a secret to everybody on board but the pilot. And the pilot even has to have a special light that flashes on to let him know. The telltale landing bump is completely eliminated!

This incredibly smooth landing results from the landing gear equipment developed by B. F. Goodrich and Lockheed engineers, working together. B. F. Goodrich *tandem twin* wheels are used with B. F. Goodrich Expander Tube brakes and B. F. Goodrich Rotovane (pre-rotation) tires on the main gear. Twins are used on the nose, making 10 wheels and tires in all.

These ten air chambers—all rotating *before* they touch the ground—take most of the shock out of landing. Landing gear shock absorbers account for the rest.

The new landing gear equipment has other big advantages, too. It saves a *ton* of weight. It provides greater safety, greater economy, and it distributes the plane's weight over a greater area of runway, enabling the Constitution to use more airports.

Complete B. F. Goodrich assemblies—tire, tube, wheel and brake—are now available. And B. F. Goodrich can engineer an assembly to best meet the needs of *any* aircraft design, big or small. For help with your problems, write to *The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER

A general method of analysis is developed for the two-dimensional, steady, compressible flow through mixed-flow compressors and turbines in which the centerline of the passage generates a right circular cone about the axis of the machine. The two-dimensional, radial-flow compressor is a special case in which the cone angle is equal to 180°. The variables taken into account are: (1) impeller tip Mach Number, (2) flow rate, (3) blade shape, (4) passage height, (5) number of blades, and (6) cone angle. Relaxation methods are used to solve the resulting nonlinear differential equation for the stream function.

Experimentelle Untersuchungen an einer axialen Gebläsestufe (Experimental Investigations of an Axial Blower Stage). Ernst Mühlemann. *Zürich, Eidgenössische Technische Hochschule, Institut für Aerodynamik, Mitteilungen Nr. 12,* 1946. 71 pp., illus., diagrs., figs. 13 references. Verlag AG Gebr. Leemann & Co., Zürich. Sw. fr. 14.–.

A detailed analysis of the losses in a single-stage axial blower. The investigation continues the work done by C. Keller on the use of airfoil theory in the analysis of axial blowers. The test setup employed two blowers. The first supplied an airflow that could be varied over the entire characteristic range of the test unit, which operated as a turbine. By reversing the blower, the flow could be kept low or made negative, as desired, without the use of a throttle. The stator and rotor under investigation were designed as components of a stage of multistage axial compressors. The impulse method, which has been used to measure the resistance of single airfoils, was adapted for turbines. Loss in the rotor was measured separately by a specially developed rotating pitot tube that measured the pressure variations in the rotor field. The critical Reynolds Number measured on the rotor blades was about 90,000. The efficiency of the stage was directly proportional to the quantity of the flow. The greatest loss occurred in the rotor. In the range of blade pitch investigated, the flow left the rotor with an angle of attack that, instead of remaining constant, increased and produced a wake with uneven energy and velocity distributions. Test apparatus, instruments, and calibration are described in detail.

Nonstationary Gas Flow in Thin Pipes of Variable Cross Section. G. Guderley. (*ZWB, Forschungsbericht Nr. 1744,* October 22, 1942.) *U.S., N.A.C.A., Technical Memorandum No. 1196,* December, 1948. 81 pp., figs.

A mathematical treatment of the method of characteristics used by F. Schultz-Grunow and R. Sauer to investigate ideal, nonstationary, isentropic gas flows in pipes of constant cross section has been used to examine nonisentropic flow in a pipe of variable cross section. The equations for the direction of the flow characteristics and the conditions obtaining along them are solved for the most general case of isentropic flows in pipes of constant cross section. By an analysis of the boundary conditions the method is extended to flow with variable cross section. By introducing the relationships that exist before and behind a compression shock, the treatment is extended to include nonisentropic flow. The phase relations of the flow at a compression shock are defined by three equations, in three variables, which are derived from the consistency conditions of each of the three characteristics that pass through any point in the flow. The compression shocks in this analysis constitute a transitional condition between successive phases of the nonisentropic flow.

Readers' Forum: The Simulation of Combustion Models in Wind Tunnels. Bruno W. Augenstein. *Journal of the Aeronautical Sciences,* Vol. 16, No. 3, March 1949, pp. 191, 192. 6 references.

The general characteristic equation for one-dimensional flow in a duct shows that the addition of heat to a steady flow can be simulated by throttling and that a change in the duct area can simulate the effects of a pressure pulse traveling through a constant-area duct with a combustion zone. Coupling or resonance oscillations between the combustion chamber and the rest of the duct, however, must be investigated with actual combustion.

PARASITIC COMPONENTS & INTERFERENCE

Flight Tests on the Effect of Surface Finish on Wing Drag. A. D. Young, J. E. Serby, and D. E. Morris. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2258,* July, 1939. 22 pp., illus., diagrs., figs. 8 references. British Information Services, New York. $1.30.

Flight tests to determine the effect of irregularities in surface finish on wing drag were made with a Battle prototype airplane at Reynolds Numbers from 12×10^6 to 18×10^6. Although camouflage paint did not affect the transition points, its drag was measurable and could reduce the top speed of the airplane by about $^3/_4$ per cent. Both snap and flush rivets increased drag by affecting transition-point positions. The drag of the flush rivets in the turbulent layer, however, was negligible, whereas that of the snap-rivet heads increased rapidly with their height. The drag of ten unchamfered rear-ward-facing lap joints $^1/_{16}$ in. high would decrease top speed by about $2^1/_2$ per cent. A 1:15 chamfer would give a reduction of about $1^1/_2$ per cent. Depending on the fineness of the fit, a leading edge slat added to half the wing span of an airplane with the transition points near the leading edge would reduce top speed between $^1/_2$ and $2^1/_2$ per cent. Formulas for estimating the drag of rivets and lap joints yield results that agree well with experimental results.

STABILITY & CONTROL

An Investigation of the Lateral Stability of Aeroplanes with Rudder Free. L. W. Bryant and R. W. G. Gandy. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2247,* December, 1939. 16 pp., figs. British Information Services, New York. $1.00.

Wind-tunnel measurements of stability derivatives made on model airplanes tend to confirm the opinion that lateral instability observed in high-speed aircraft is caused by the relation between the aerodynamic balance of the rudder and the derivatives of static directional stability and of rudder power. The more delicate the balance, the more difficult it is to avoid instability. For a given degree of balance, the rate of change of the hinge moment with the sideslip must lie between two limits of opposite sign to ensure rudder-free stability. When the rate is too high and has the sign usually associated with horn balance, short-period oscillations appear, but when the rate has the opposite sign, long-period oscillations arise accompanied by considerable rolling. An increase in the size of the fixed fin and reduction of moving surface exerts a stabilizing effect. Mass balancing also stabilizes but has a detrimental effect on the longer-period oscillations. Direct damping of the rudder motion tends to destabilize the airplane. Hence, friction in the rudder control system may determine whether an airplane is stable or unstable, since these friction forces are likely to be large compared to the air-damping forces acting on the rudder.

A Simplified Theory of the Lateral Oscillations of an Aircraft with Rudder Free, Including the Effect of Friction in the Control System. S. Neumark. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2259,* May, 1945. 39 pp., figs. 18 references. British Information Services, New York. $2.20.

A development of the work of Greenberg and Sternfield (published by the N.A.C.A.) on the rudder-free dynamic stability of an airplane with special reference to the effect of friction in the rudder control system. By changing some of the coefficients of the equations for the frequency and damping of the lateral oscillations of an aircraft, the lateral motion of the center of gravity and the rolling moment of the aircraft can be taken into account without raising the order of the equations. The corrected coefficients for the rudder-fixed case are obtained by determining the quadratic equation by factorizing the exact stability quartic. The rudder-free case is then derived by the use of approximate relationships for the effect of rudder-effectiveness parameters, rudder damping, and rudder-yaw damping. Friction in the control system of an undamped rudder may cause stable and unstable oscillations, even though the values of the floating-moment parameter and the restoring-moment parameter lie between the boundary for increasing oscillations and the boundary for complete damping. Simple, practical, approximate formulas are developed from which the frequencies and amplitudes of both types of oscillation may be found.

Wind-Tunnel Investigation of Effects of Tail Length on the Longitudinal and Lateral Stability Characteristics of a Single-Propeller Airplane Model. Harold S. Johnson. *U.S., N.A.C.A., Technical Note No. 1766,* December, 1948. 109 pp., illus., diagrs., figs. 8 references.

Lift, drag, and pitching-moment data; the neutral points; the effect of power, of flap deflection, and of free elevator at zero angle of yaw; lateral-stability parameters; yaw range; and rudder-free data were obtained from wind-tunnel tests made with a model of a low-wing airplane. The destabilizing shift in neutral point which was caused by power increasing as the tail length increased when either the horizontal tail volume or the horizontal

ONE Source, ONE High Quality, for Virtually Every Instrument in Your Flight Engineer's "Office"

The nerve center in the huge and complex aircraft of today is the Flight Engineer's instrument panel. To assure you the utmost in uniformity and accuracy in this vital spot, Eclipse-Pioneer provides precision remote indicating systems for practically every engine function required. Each instrument is an example of the skill and craftsmanship that have built Eclipse-Pioneer's reputation—one of the oldest and finest in the field. When you specify these all-important engine instruments for your planes, give yourself every advantage by selecting Eclipse-Pioneer—one source, one high quality for all.

ECLIPSE-PIONEER DIVISION OF

TETERBORO, NEW JERSEY

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York

AVIATION CORPORATION

LOOK FOR THE PIONEER *MARK OF QUALITY*

REG. U.S. PAT. OFF.

tail area was kept constant. For a given tail length the destabilizing shift increased with increasing tail area. The increase in directional stability caused by power became larger as the tail length increased. At positive angles of yaw the tendency toward rudder lock decreased as the tail length increased. In the negative yaw range, variation of tail length had practically no effect on rudder lock.

Flight Measurements of the Stability, Control, and Stalling Characteristics of an Airplane Having a 35° Sweptback Wing Without Slots and with 80-per cent-Span Slots and a Comparison with Wind-Tunnel Data. S. A. Sjoberg and J. P. Reeder. *U.S., N.A.C.A., Technical Note No. 1743*, November, 1948. 85 pp., illus., diagr., figs. 3 references.

Measurements were made on a 1/4.5 scale model in the Langley 300 m.p.h. 7 by 10-ft. wind tunnel. Directional stability, with or without slots and with flaps up or down, was satisfactory at all test speeds. A part of the decrease in directional stability that was observed with decrease in speed was due to the unstable yawing moments that were caused by the large aileron deflections required for trim in steady sideslips at low speed. A large increase in dihedral effect occurred with increase in normal-force coefficient. Agreement between flight and wind-tunnel measurements of the dihedral effect was good for the wing with the slots and fair for the wing without the slots. Stalling characteristics of the airplane were good with flaps up or down when the 80 per cent span slots were on the wing.

Some Problems of the Stability and Control of Large Aircraft. D. J. Lyons. *Royal Aeronautical Society, Journal*, Vol. 52, No. 455, November, 1948, pp. 723–734, figs.

The control forces required to maintain the stability of an aircraft increase with the size of the aircraft. When the wing span is greater than 100 ft., with a wing loading over 30–40 lbs. per sq.ft., the provision that must be made to keep stick forces within the range of a pilot's physical ability presents serious design problems. Fixed-balance, manually-operated controls, require such delicate balance that the accretion of ice on the control surfaces rapidly produces overbalance. As the gross dimensions increase the fineness of the required balance can exceed that which can be obtained with current manufacturing tolerances for production aircraft. Spring tabs, instead of fixed balance, give satisfactory performance with wing spans not in excess of 200 ft., and servo tabs can be used with wing spans up to 300 ft. Power controls, however, are a solution to the problem which is not subject to the limitations of aircraft size. The seriousness of a system failure with this control, however, is greater than with other types of control, but adequate safety can be assured by the installation of a parallel, independent emergency circuit. Since power systems have no inherent "feel," provisions should be made by which an artificial "feel" could be adjusted so that the control-system stability would correspond generally to the stick-fixed stability of the basic aircraft. Automatic limit stops could prevent excessive control-surface deflection and runaway controls.

Stability and Control Characteristics at Low Speed of an Airplane Model Having a 38.7° Sweptback Wing with Aspect Ratio 4.51, Taper Ratio 0.54, and Conventional Tail Surfaces. Vernard E. Lockwood and James M. Watson. *U.S., N.A.C.A., Technical Note No. 1742*, December, 1948. 155 pp., illus., diagrs., figs. 8 references.

A wind-tunnel investigation of the static characteristics of a 1/4.5 model airplane. The effects of leading-edge slots, a circular-arc wing, drooped leading edges, change of tail length, and change of fin area on the aerodynamic characteristics were determined, and the wing-fuselage interference effect on effective dihedral was analyzed. The lift-curve slope of the swept-wing model compared favorably with the calculated value obtained by multiplying lift-curve slope for the unswept wing by the cosine of the angle of sweep. The maximum lift coefficient for the swept-wing model with no auxiliary lifting device compared favorably with that of the unswept-wing model, and the angle of attack for which the maximum lift coefficient occurred was in good agreement with a theoretical value obtained from an empirical cosine relationship.

Effects of Compressibility on Normal-Force, Pressure, and Load Characteristics of a Tapered Wing of NACA 66-Series Airfoil Sections with Split Flaps. F. E. West, Jr., and J. M. Halissy, Jr. *U.S., N.A.C.A., Technical Note No. 1759*, December, 1948. 44 pp., illus., diagrs., figs. 15 references.

Results of wind-tunnel tests of a 12-ft.-span tapered wing of NACA 66-series airfoil sections at Mach Numbers up to 0.69 at an angle of attack of −4° through the stall. Both 55 per cent span and 98 per cent span flaps deflected 60° and having chords of 20 per cent were tested. The normal-force curves were similar. As the Mach Numbers increase from 0.145 to approximately 0.300, the maximum lift coefficients of both increase and then decrease rapidly. From this point to Mach Number 0.485, the maximum lift coefficient of the 55 per cent span remains constant while that of the 98 per cent span increases slowly. At 0.485, both rise rapidly. There is further evidence that the rapid rise is due to the sharp leading edge of the wing. Shift of lateral center of normal force for angles of attack below the stall was slight, and the maximum variations of either the flap normal-force or the hinge-moment coefficient with the wing normal-force coefficient were less than 20 per cent and 10 per cent, respectively.

Prediction of the Effects of Propeller Operation on the Static Longitudinal Stability of Single-Engine Tractor Monoplanes With Flaps Retracted. Joseph Weil and William C. Sleeman, Jr. *U.S., N.A.C.A., Technical Note No. 1722*, October, 1948. 42 pp., diagrs., figs. 15 references.

Wind-tunnel investigation of 28 powered model aircraft to determine the effects of propeller operation on the static longitudinal stability of single-engined tractor monoplanes led to the development of a method for computing power-on pitching-moment curves for flap-retracted flight conditions. The effects of power on the down-wash over the tail and the stabilizer effectiveness can be calculated from correlation curves. The power-on longitudinal stability characteristics that are predicted by this method are generally in good agreement with experiment.

THERMO-AERODYNAMICS

A Method for Determining the Rate of Heat Transfer From a Wing or Streamline Body. Charles W. Frick, Jr., and George B. McCullough. *U.S., N.A.C.A., Report No. 838*, 1945. 10 pp., illus., figs. 9 references. U.S. Govt. Printing Office, Washington. $0.15.

WINGS & AIRFOILS

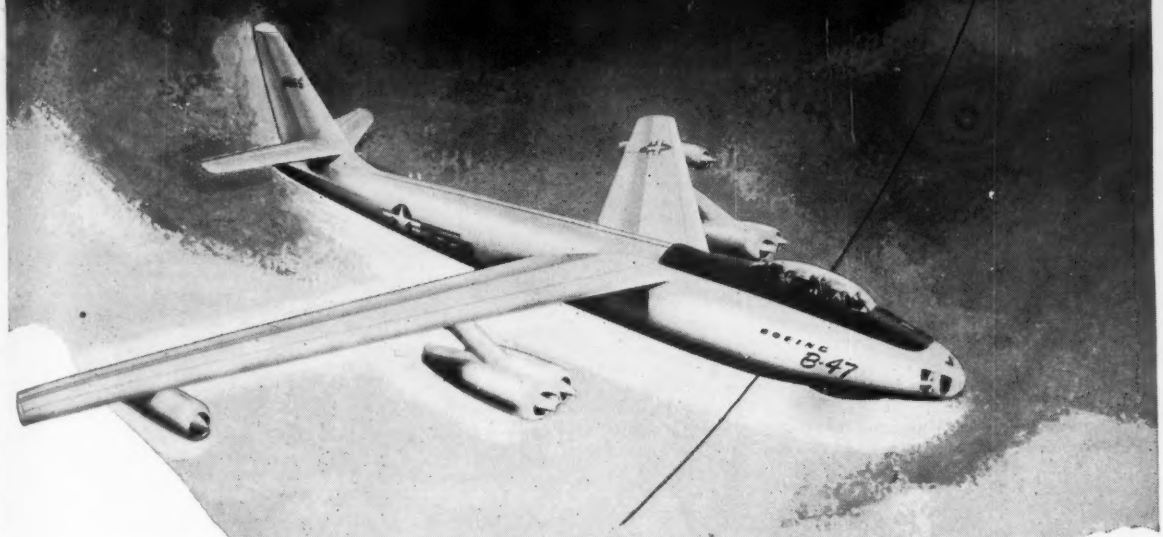
Stability Derivatives of Thin Rectangular Wings at Supersonic Speeds; Wing Diagonals Ahead of Tip Mach Lines. Sidney M. Harmon. *U.S., N.A.C.A., Technical Note No. 1706*, November, 1948. 33 pp., figs. 16 references.

Linearized theory is used to obtain the surface-velocity-potential functions, the surface-pressure distributions, and stability derivatives for various motions at supersonic speeds of thin, flat, rectangular wings without dihedral. The investigation includes steady and accelerated vertical and longitudinal motions and steady rolling, yawing, sideslipping, and pitching at Mach Numbers and aspect ratios greater than those for which the Mach line from the leading edge of the tip section intersects the training edge of the opposite tip section. The positive yawing at supersonic speeds, in contrast to the behavior at subsonic speeds where a positive rolling moment would be produced, may produce a negative rolling moment. At supersonic speed a significant change is produced in the positive direction of yawing moment per unit rolling velocity.

The Development of Cambered Airoil Sections Having Favorable Lift Characteristics at Supercritical Mach Numbers. Donald J. Graham. *U.S., N.A.C.A., Technical Note No. 1771*, December, 1948. 82 pp., figs. 5 references.

A new group of airfoil sections that have favorable lift characteristics at supercritical Mach Numbers has been designated the NACA 8-series. Negative camber over a portion of the airfoil chord holds the lift coefficient approximately constant as the Mach Number increases to values as high as 0.9. A particular variation with Mach Number of the angle of attack required to maintain a given design lift coefficient can be obtained by suitable choice of camber and thickness distributions. The lift-curve slope has not been improved over that of the NACA 6-series sections, and, although some control can be exercised over the drag and pitching-moment without adversely affecting the lift characteristics, it is generally necessary to accept, in the 8-series, a divergence of the drag with Mach Number which is somewhat inferior to that of the NACA 6-series. However, since the variations of pitching-moment coefficient with Mach Number and angle of attack at supercritical Mach Numbers of the new series are somewhat smaller, they are generally more favorable than those characteristic of the NACA 6-series. The lift characteristics of the NACA 8-series airfoils at supercritical Mach Num-

An Engineer's Dream becomes a Proved Reality!



Engineers have long dreamed of a jet bomber that could fly at jet fighter plane speed. In the USAF Boeing B-47 Stratojet this dream has been realized. Recently this "light" bomber flew from Moses Lake, Washington, to Andrews, Maryland—a matter of 2,289 miles in 3 hours and 46 minutes averaging 607 miles per hour.

Such amazing speed demands two contradictory qualities of every element in the structure—extremely rugged construction with weight reduced to an absolute minimum. This necessitates a refinement in design—a precision that approaches laboratory perfection.

The production of the power units to retract the landing gear—the landing gear actuators—the slat drive—the flap screws—the controls for the wing flap system—was entrusted to Foote Bros.

Here is another example of the ability of Foote Bros. to meet unusual demands in the production of better power transmission equipment. The experience of this company goes back nearly a century, and today Foote Bros. offers American industry complete engineering and manufacturing facilities for producing gears in almost any type and size—enclosed gear drives in a wide range of sizes and ratios—and the ability to engineer special drives to meet practically any transmission problem.

FOOTE BROS. GEAR AND MACHINE CORP.
Dept. G, 4545 S. Western Ave., Chicago 9, Illinois

FOOTE BROS.

Better Power Transmission Through Better Gears

bers can be approximated with NACA 6-series airfoils by using negatively-deflected plain trailing-edge flaps. Thus, the favorable variation, with Mach Number, of the lift coefficient at a given angle of attack, characteristic of the NACA 8-series airfoils, could be obtained on demand without sacrificing, at other times, the superior drag characteristics of the NACA 6-series airfoils.

The Effects of Variations in Reynolds Number Between 3.0×10^6 and 25.0×10^6 Upon the Aerodynamic Characteristics of a Number of NACA 6-Series Airfoil Sections. Laurence K. Loftin, Jr., and William J. Bursnall. *U.S., N.A.C.A., Technical Note No. 1773*, December, 1948, 42 pp., figs. 9 references.

An investigation to determine the two-dimensional lift and drag characteristics of nine NACA 6-series airfoil sections. Although the airfoils of 12 per cent thickness and less had the same type of scale-effect curves, the Reynolds Number at which the different effects predominated varied. The 18 per cent thick section had a type of maximum lift variation with Reynolds Number entirely different from the thinner sections. Any comparison of airfoil maximum-lift characteristics can be made only if the data are available at the same Reynolds Number.

Rotary Derivatives of a Delta Wing at Supersonic Speeds. A. Robinson. *Royal Aeronautical Society, Journal*, Vol. 52, No. 455, November, 1948, pp. 735–752, figs. 9 references.

Linearized theory is used to investigate the characteristics of a delta wing at supersonic speeds. Two cases are distinguished. In the first, the apex semiangle of the airfoil is smaller than the Mach angle, a condition that exists when the airfoil first enters the supersonic regions. The second case applies to those higher supersonic speeds at which the apex semiangle is greater than the Mach angle. The analysis of the second case employs the principle of independence. A set of equations is obtained for each case which expresses the damping derivative of rolling moment with the rate of roll, the damping derivative of pitching moment with the rate of pitch, and the total lift on the airfoil.

Letters to the Editor: Drag of an Airfoil in Accelerated, Supersonic Flight. C. S. Gardner, H. F. Ludloff, and F. Reiche. *Journal of Applied Physics*, Vol. 19, No. 12, December, 1948, pp. 1179, 1180.

By the introduction of coordinates that are fixed in the airfoil into the equation for the supersonic source distribution of the perturbations caused by a thin airfoil moving at constantly accelerated supersonic speed into still air, the evaluation of complicated combustions of elliptic integrals is eliminated. The initial velocity and time do not appear explicitly in the expression for the drag of the airfoil. The contributions of the initial and subsequent acceleration are combined in a single term. This permits a quasistationary treatment for the first power of the acceleration.

Note on the Limits to the Local Mach Number on an Aerofoil in Subsonic Flow. A. D. Young. **Addenda and Corrigenda.** *College of Aeronautics, Cranfield, England, Report No. 14*, October, 1948. 2 pp., fig.

Air Transportation (41)

U.S. Planes Fly World Routes. *Aviation Week*, Vol. 49, No. 21, November 22, 1948, pp. 38, 39. Includes tabulation of the number of principal types of transport aircraft in service on the scheduled air lines of the world and the number of aircraft in operation on scheduled air lines, excluding Alaska and Russia.

TWA Perfects Instant Reservations System. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, p. 14, illus.

Spokesman for the Business Plane. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, p. 35, illus. Organization and program of the Corporate Aircraft Owners Association.

PAA-AOA Deal Now Up to Government; Pan American to Buy Atlantic Rival With a Stock Transfer Involving No Cash Payment. William Kroger. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, pp. 12, 13.

Atomic Project Airline. Tom Ashley. *Southern Flight*, Vol. 30, No. 6, December, 1948, pp. 8–10, 30–32, illus.

The utility of single-engined aircraft in providing connecting passenger, mail, and light freight express service for small cities. "Carco Air Service" employs six Bonanzas and two Beechcraft Twins in nonscheduled operations from Albuquerque's West Mesa Airport to Los Alamos, N.M.

Air Cargo Sales Forms and Records. Richard H. Rush. *Aviation Maintenance & Operations*, Vol. 2, No. 1, December, 1948, pp. 34–36, facsimiles.

Milk From Ireland; An Air and Road Operation; Successful Distribution Organization. *Modern Transport*, Vol. 60, No. 1545, November 6, 1948, p. 8, illus. Organization of the airplane-truck distribution system used to transport fluid milk from the North of Ireland to England.

Air Express and Rea. John H. Frederick. *Distribution Age*, Vol. 47, No. 12, December, 1948, pp. 42, 64, 65.

The decision of the Civil Aeronautics Board to continue its authorization of the air-express services performed by the Railway Express Agency also directed a revision of the method of allocating revenue between the airlines and the express agency. This may bring about a downward revision of air-express tariffs.

Another Record for U.S. Freight; Survey Indicates Heavy Increase Over 1947 Ton Mile Level; Scheduled Carriers Account for Most of Gain. Charles Adams. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, pp. 37, 38.

The Contribution Made by Aviation to the Economic Development of Canada. W. B. Burchall. *Shell Aviation News*, No. 125, November, 1948, pp. 7–11, illus. Forestry, aerial photography and survey, aerial mapping, fisheries, mining development, air lines, and social services.

Pakistan's Civil Aviation. S. Kureishi. *Indian Skyways*, Vol. 2, No. 10, October, 1948, pp. 49, 51.

The Rehabilitation of European Air Transport. J. F. Parke. *Institute of Transport, Journal*, Vol. 23, No. 1, November, 1948, pp. 18–22.

Is the Sun Setting on India's Aviation? *Indian Skyways*, Vol. 2, No. 10, October, 1948, pp. 34–36, 39, 41, illus. The problems of the commercial operator.

Airplane Design & Description (10)

Electrical Prerotation of Landing Gear Wheels. J. H. Keyser, Jr. *Electrical Engineering*, Vol. 67, No. 12, December, 1948, pp. 1154–1159, figs. 2 references.

Test results show that prerotation of landing-gear wheels can reduce the horizontal component of structural loads at landing from 41 to 11 per cent. Vanes on the tire or on the landing-gear wheel which utilize aerodynamic forces to impart prerotation are unsatisfactory as a primary drive at landing speeds under 100 m.p.h. Above this speed the vanes produce only partial prerotation. Analysis of the effect of air speed on the torque that is required to maintain prerotation shows that an electric motor used for this purpose would be required to operate for a relatively long time at low speed and deliver high torque. These requirements are fulfilled by a direct-drive "Dever" motor, developed for the Lockheed Constitution, which employs a ring-wound armature and a compound-wound stator mounted on the brake flange.

Goodyear's Cross-Wind Landing Wheel. O. W. Laudenslager. *SAE Journal*, Vol. 56, No. 12, December, 1948, pp. 39–42, diagrs. (Extended summary of a paper: Development of the Goodyear Cross-Wind Landing Wheel.)

New Design Principles Shape Simpler Cockpit. T. D. Davies. *SAE Journal*, Vol. 56, No. 12, December, 1948, pp. 48–52, diagrs. (Extended summary of a paper: A New Approach to Cockpit Layout—An Analytical Approach.)

Low-Drag Accented in All-Wing. Robert McLarren. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, pp. 21–24, illus. Advantages in speed, range, and pay load of all-wing aircraft and the progress that has been made in solving the stability and control problems that this configuration has introduced.

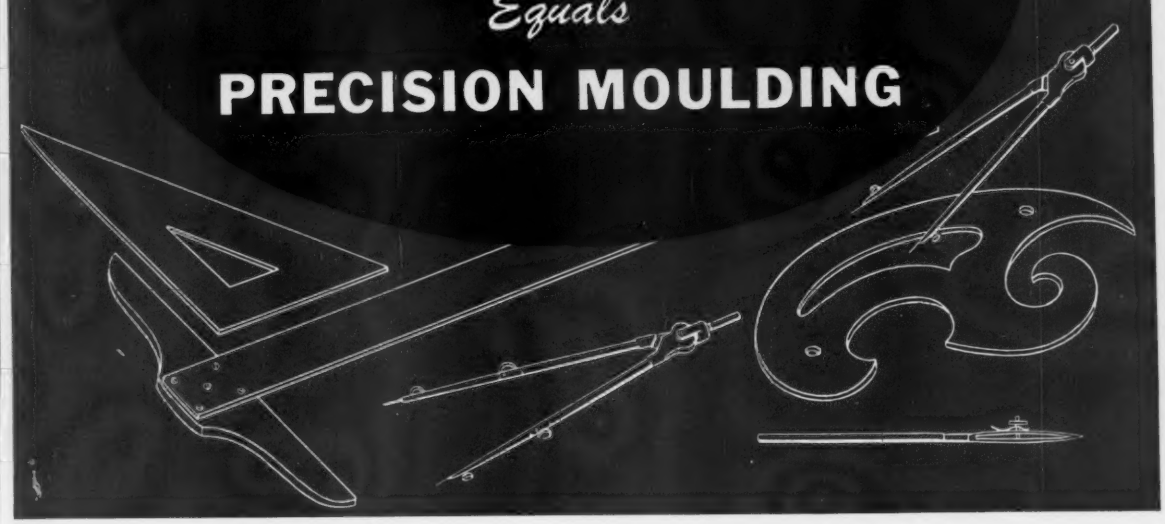
Miniature Airliner of 195-? Fred K. Dick. *Southern Flight*, Vol. 30, No. 6, December, 1948, pp. 12, 13, 22, illus., diagrs. Design possibilities for the executive-type airplane.

This Quest for Speed. J. Lloyd. *Hawker Siddeley Review*, Vol. 1, No. 4, November, 1948, pp. 6–10, illus., diagrs. Review of the changes in aircraft design that have accompanied increased flight speed and of present trends that may hold the solution to the problems of economical supersonic aircraft.

Cost Control Spotlights the Design Stage. John Van Hamersveld. *The Martin Star*, November, 1948, pp. 10, 11, 18, figs.

The Design Cost Control group in the Engineering Division of The Glenn L. Martin Company plant prepare cost analyses of engineering designs and new manufacturing methods in order to determine which design decisions will permit the most economical manufacture and to standardize economical designs. The group issues bulletins that provide the designer with check lists for the evaluation of their designs and give comparative cost of materials and standard parts. The potential savings to be effected by this

CORRECT DESIGN
Plus
LABORATORY CONTROL
Equals
PRECISION MOULDING



Regardless of the size of the job, if it's accuracy you need to minimize your assembly problems or to improve the performance of your production units—if ease of installation and lower rejection rates are the keynote of your production program — *then call LINEAR* for that precision moulded natural or synthetic rubber product.

But dimensions held to close tolerances is not the complete story! For those unusual conditions requiring a seal with a wide temperature range from −320°F. to +400°F. against concentrated sulphuric, hydrofluoric, hydrochloric and other vigorous oxidizing materials, LINEAR is moulding Kel-F, Teflon and Silicone rubber in "O," "V," "U" and other shapes. Where Kel-F, Teflon or Silicone is the answer—*again call LINEAR.*

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK STREET, PHILADELPHIA 35, PA.

group on 1 year's anticipated contract quantities was $1,600,000 at a cost in man power of only $20,000.

Problems of the Ultra-Light Aeroplane. A. R. Weyl. *Sailplane and Glider*, Vol. 16, No. 12, December, 1948, pp. 11–13.

Modern Czech Aircraft. H. Manley. *Skyways*, Vol. 8, No. 1, January, 1949, pp. 36–39, 59, illus.

The Airspeed Ambassador. A. N. Werner. *The Log*, Vol. 8, No. 12, December, 1948, pp. 281–285, illus.

New Pusher Tested for Certificate; Anderson Greenwood 14. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, p. 22, illus.

An Ideal Personal Plane (Atlas H-10)? *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, p. 23, illus.

The (Avro) C-102 Progresses. *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, pp. 18, 20, illus.

Beech Model 45: A Military Trainer. *Aviation Week*, Vol. 49, No. 25, December, 1948, p. 16, illus.

Double-Deck Airliner (Boeing Stratocruiser). Frederick B. Collins. *Flying*, Vol. 44, No. 1, January, 1949, pp. 34, 35, 64, illus.

The Stratofreighter (C-97) Air Duct and Antiicing Systems; The Method of Manufacture and Installation of the Plastic Ducts Developed by the Boeing Aircraft Company. H. W. Perry. *Aircraft Engineering*, Vol. 20, No. 237, November, 1948, pp. 335, 336, illus.

Navy Unwraps its Fastest Fighter (Twin-Jet Chance-Vought Cutlass XF7U-1). Robert Hotz. *Aviation Week*, Vol. 49, No. 22, November 29, 1948, pp. 12, 13, illus.

Navy's New "Flying Wing" Fighter (Chance-Vought XF7U-1) First Tests. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 24, December 15, 1948, p. 6, illus.

Chase Tests New Cargo Plane (YC-122 Assault Transport). *Aviation Week*, Vol. 49, No. 22, November 29, 1948, p. 14, illus.

Convair (T-29) Trainer. *Aviation Week*, Vol. 49, No. 24, December 13, 1948, p. 21, diagrs.

Doves for Survey and Pest Control. *de Havilland Gazette*, No. 48, December, 1948, pp. 12, 13, illus., diagr.

Significant Vampire Developments. *de Havilland Gazette*, No. 48, December, 1948, pp. 6, 7, illus., diagr., figs.

XT-30 (Douglas Trainer) Is Completed. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, p. 14, illus.

Gloster 'Meteor 4' Fighter. *Hawker Siddeley Review*, Vol. 4, No. 1, November, 1948, pp. 27, 28, illus., diagr. Specifications, table of weights and loads, and table of performance.

Luscombes for 1949. *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, pp. 28, 29, illus.

Four-Engined Lightplane (Monsted-Vincent Star Flight). *Flying*, Vol. 44, No. 1, January, 1949, p. 56, illus.

The C-125 Raider (Northrop Assault Transport). *Plane Facts*, Vol. 5, No. 11, November, 1948, pp. 20, 21, illus.

The Short Sealand (Amphibian). *Shell Aviation News*, No. 125, November, 1948, pp. 20, 21, illus.

"Tribian" Amphib (Sponson) Attracts Wide Interest. *Aviation Week*, Vol. 49, No. 23, December 6, 1948, pp. 20, 22, diagr.

Airports & Airways (39)

Night-Landing Helicopters. *Flight*, Vol. 54, No. 2085, December 9, 1948, p. 688, illus.

An experimental night-landing floodlight and wind-direction indicator. Its circle of light, 120 ft. in diameter, illuminates vertical surfaces sufficiently for a helicopter pilot to discern the texture of the ground during a landing. The shadow cast by the wind-direction indicating vane is visible from an altitude of about 1,000 ft.

Slope Line Light Approval Near. *Aviation Week*, Vol. 49, No. 23, December 6, 1948, pp. 15, 16, illus. The Airport Lighting Evaluation Panel has recommended purchase of the slope-line airport approach-lighting system developed by the C.A.A. and its adoption as standard equipment for civil and military use.

High Intensity Runway Lighting (LM-Bartow) at General Mitchell Field. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, p. 36, illus.

Large Airport Lighting and Distribution. *Westinghouse Electric Corp., Publication No. B-3573-A*, May, 1948. 50 pp., illus., diagrs., figs.

Description of the complete electrical equipment required within the boundaries of an airport by C.A.A. and AN specifications. Includes typical lighting plans and wiring diagrams and a runway equipment selection chart for noninstrument and one-instrument runway airports.

World's Largest Runway Completed at Wright-Patterson Air Force Base. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 23, December 1, 1948, p. 7, illus.

Operation Flannels! Joseph M. Chase. *Aviation Maintenance & Operations*, Vol. 2, No. 1, December, 1948, pp. 21–23, 67, illus. Organization of personnel and equipment for snow removal duty at New York International Airport.

All-Weather Airways Organization. Robert Hotz. *Aviation Week*, Vol. 49, No. 21, November 22, 1948, pp. 14, 15, chart.

An outline of the plan under which the Air Navigation Development Board will coordinate research and development on a common airways system for the use of civilian and military aircraft during peacetime and on special military equipment to be integrated in wartime to accommodate both tactical military operations and nontactical transport operations.

What All-Weather Airways System Needs. Robert Hotz. *Aviation Week*, Vol. 49, No. 23, December 6, 1948, pp. 12–14, diagrs. Current status of the navigation-aids development program of the Radio Technical Commission for Aeronautics.

Airport Capital Improvements. Leigh Fisher. *Aviation Maintenance & Operations*, Vol. 2, No. 1, December, 1948, pp. 30, 68, 70.

Rational Air Terminal Design. Walther Prokosch. *SAE Journal*, Vol. 56, No. 12, December, 1948, pp. 55–57, diagrs. (Extended summary of a paper: Air Terminal Design—A Selective Method of Planning.)

Hydrant Refueling System. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, p. 21, illus. Esso demonstration at McGuire Air Force Base, Fort Dix, N.J.

Hydrant Refueling at Moisant Airport. *Southern Flight*, Vol. 30, No. 6, December, 1948, pp. 26, 27, illus., diagrs.

The conventional pit system is replaced with that of piping from central fuel storage to a hydrant that is attached to the intake hose of a mobile hose cart. Advantages over the tank-truck method are displayed.

Atomic Energy (48)

Atomic Engines for Aircraft. Andrew Kalitinsky. *Flying*, Vol. 44, No. 1, January, 1949, pp. 22, 52–54, diagrs.

Aviation Medicine (19)

Scientific Methods for Use in the Investigation of Flight Crew Requirements. David Morrison, Project Engineer. *Flight Safety Foundation, Inc., Woods Hole, Mass., Project No. RP-1-F*, November, 1948. 113 pp., diagrs., figs. $5.00.

Aspects of aeronautical cybernetics: study of crew members in real and simulated flight conditions with the use of methods of medical research and psychology and of recording and analyzing related data to evaluate human behavior requirements in large transport aircraft. Dependence upon these techniques for a comprehensive approach to this aspect of aviation's man-machine relationship can be expected to the fullest possible extent. Contents: Part I, Medicine: Application of Medical Research to the Determination of Flight Crew Requirements of Large Aircraft, Emerson Day and Shannon C. Allen; The Influence of Hormones on the Ability of the Individual to Withstand Stress, David Hume. Part II, Psychology: Techniques for Collecting and Interpreting the Judgment of Pilots and Others Regarding a Third Crew Member, Rensis Likert and E. Lowell Kelly; Motion Photography—A Method for Analyzing Air Crew Duties, Ralph Channell; The Sampling Method of Activity Analysis and its Application to the Problem of Aircraft Crew Requirements, J. M. Christensen; Motion Study Techniques Which Could be Brought to Bear on Desirable Size of Aircraft Crews, M. E. Mundel; Systems Research, Clifford T. Morgan; Objective Flight-Check Techniques, John C. Flanagan and Thomas Gordon; Observations on an Experimental Approach to the Study of Skill Fatigue in the Flight Crews of Civil Air Transports, R. A. McFarland and J. I. Niven. Part III, Related Methods: Flight Test Engineering Principles Applicable to the Investigation of Crew Requirements; Laboratory Equipment for Human Engineering Research, E. A. Link; Application of Punched-Card Equipment to the Automatic Accumulation and Analyses of Extensive and Complex Data, M. L. Wood.

AIR-BORNE SELF-STARTER FOR JETS

A successful air-borne, self-starting system for jet and turboprop aircraft engines was recently announced by the Navy's Bureau of Aeronautics.

Developed and manufactured by AiResearch, this device makes it possible to start jet and turboprop aircraft without the use of a jeep-drawn trailer of storage batteries, 250-lb. generator and ground crew. The new system saves valuable time, equipment and personnel and allows such aircraft to be started anywhere, any time, and under any conditions.

Heart of the new self-starter system is a newly developed 88-lb. multi-purpose auxiliary gas turbine—the first radial *inward flow* power turbine of the air or gas type ever perfected. It is the *first* auxiliary gas turbine of *any type* to pass gruelling 200-hour government qualification tests. Combustion temperatures as high as 1600° F and wheel speeds as fast as 40,000 rpm make possible its very high ratio of power for weight and size.

• AiResearch engineers, designers of rotors operating in excess of 100,000 rpm, invite your toughest problems involving high-speed wheels. Specialized experience is also available in creating compact turbines and compressors; actuators with high-speed rotors; air, gas and fluid heat exchangers; air pressure, temperature and other automatic controls.

Write: AiResearch Manufacturing Company, Los Angeles 45, California

AiResearch
DIVISION OF
THE GARRETT CORPORATION

A Review of the Physiological Principles Underlying Pressure Breathing, With a Brief Comparison of the Intermittent and Continuous Pressure Types. Edward V. Johnston. *Contact*, Vol. 6, No. 4, July, 1948, pp. 24–36, illus., figs. 35 references.

Physiological alterations resulting from the use of breathing equipment. Hyperventilation occurs with the intermittent type and fatigue of the expiratory muscles with the continuous type. It is possible that hyperventilation is less advantageous in the presence of severe anoxemia, but there is no question about its undesirability at altitudes at which anoxemia is slight or absent. The problem of pressure breathing is still controversial.

Research Resume. *Contact*, Vol. 6, No. 4, July, 1948, pp. 10–14, illus. Programs under way at the U.S. Naval School of Aviation Medicine, Pensacola, Fla., which deal with disorientation in pilots, speech intelligibility, and physiological problems such as decompression illness, cardiovascular phenomena, and respiration.

Wind Chill. Arnold Court. *American Meteorological Society, Bulletin*, Vol. 29, No. 10, December, 1948, pp. 487–493. 6 references.

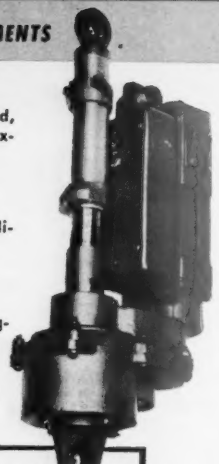
The Wind Chill formula, proposed by Siple, is an empiric expression for the dry convective cooling-power of the atmosphere which is based on observations made at temperatures lower than those used by other investigators in the field, provides only a qualitative description of the relative severity of combinations of wind and low temperatures, and probably never accounts for more than 80 per cent of the total body-heat loss. For the construction of accurate quantitative maps of wind chill distribution for months or seasons, a formula is required that will account accurately for all the physiological factors involved. The desirability and significance of such maps is uncertain, because, even if it were possible to compute theoretically the total body heat loss from all avenues of transfer, the direct correlation of such data with human comfort would have to encompass the subjective sensation of the individual.

Bone Study for Safer Plane Designs (N.B.S.). *Plane Facts*, Vol. 5, No. 11, November, 1948, pp. 13–15, 32, figs.

Custom-Built ★

MOTORS, ACTUATORS ★

FOR YOUR DESIGN REQUIREMENTS



SPECIAL MOTORS . . .
Drip proof, splash proof, totally enclosed, vapor seal, submersible, high and low extremes of operating temperatures.

SPECIAL GEARING . . .
Speed range of 30,000 to 1 R.P.M., helical spur, bevel and planetary type.

COMPLETE POWER PACKAGE UNITS
For A.C. or D.C. power source with magnetic clutches and brakes, built in limit switches, potentiometers, thermal overload relays, radio noise filters, pressure tight shaft seals with linear or rotating power takeoff.

HOOVER POWER UNITS ARE SPECIFIED EQUIPMENT ON THE FASTEST AIRCRAFT FLYING
This 12.5-pound tail stabilizer actuator is designed to withstand an ultimate load of 15,000 pounds, an example of the severe load requirements Hoover power units are called upon to meet.

Whatever your electrical actuation problem, a Hoover unit will do the job. They can be supplied in experimental or production quantities.

HOOVER ELECTRIC COMPANY
2100 South Stoner Avenue • Los Angeles 25, California

Geography—Armies and Disease. William H. Powell, Jr. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 28–38.

Comfortization (23)

Cabin Conditioning Problems at Supersonic Velocities. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 24, December 15, 1948, p. 5.

Tudor IV Pressurisation. A. W. J. Smith. *The Technical Instructor*, Vol. 3, No. 11, November, 1948, pp. 17–19. Operation of equipment within an altitude range of 25,000 ft. for cabin conditions stabilized at 8,000 ft.

Education & Training (38)

Training in Aircraft Production; The New Department of Aircraft Economics and Production at the College of Aeronautics, Cranfield; Its Genesis, Aims and Organization. J. V. Connolly. *Aircraft Production*, Vol. 10, No. 122, December, 1948, pp. 399–403, illus., diagr., fig.

Financing Flight Training. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, p. 33, illus.

Your Job in Aviation; A Long-Range Forecast of Aviation Employment. Herman B. Byer. *Flying*, Vol. 44, No. 1, January, 1949, pp. 26–28, 61–63, illus. Specific jobs in air transportation and a brief summary of manufacturing needs.

Electronics (3)

Development of Single-Receiver Automatic Adcock Direction-Finders for Use in the Frequency Band 100-150 Megacycles per Second. R. F. Cleaver. *Electrical Communication*, Vol. 25, No. 4, December, 1948, pp. 337–362, illus., diagrs., figs. 14 references.

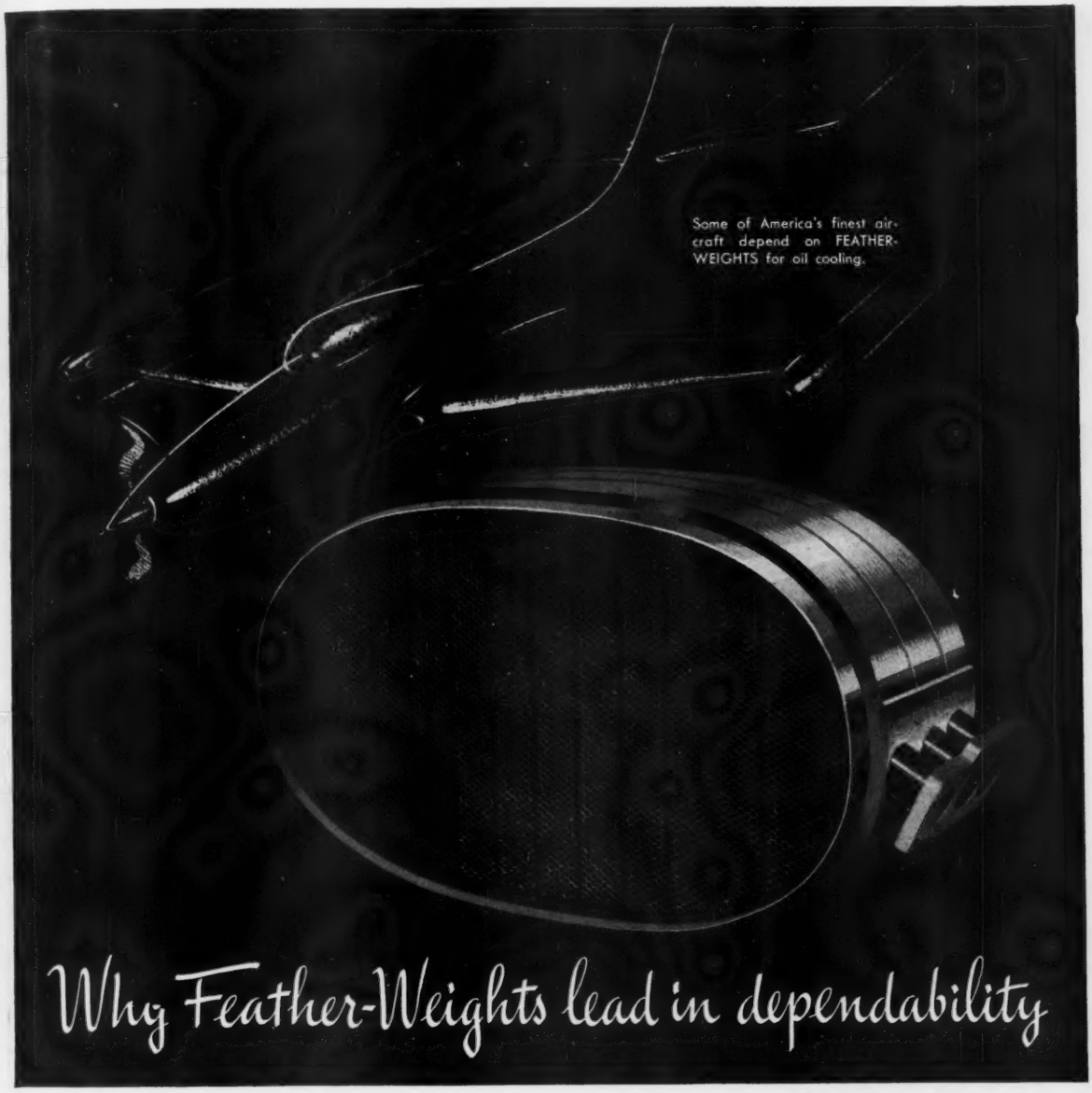
An automatic direction finder for airport traffic control which measures bearings of aircraft on signals transmitted in the 100 to 150 megacycle bands. Signals from a fixed elevated H Adock antenna are amplified in a common channel that incorporates modified two-tone balanced modulation to give cathode-ray-oscillograph display. After correction for octantal error, the probable instrumental error is less than 1.5°, and satisfactory bearing indications can be obtained from signals of field strengths as low as 7 microvolts per m. at the frequency of minimum sensitivity. The accuracy of the system is not critically dependent on the single transmission line from the antenna system to the receiver, and the system has simple and stable circuit adjustments. The display is nonambiguous, and its time constant can be adjusted within wide limits. The equipment is intended for unattended operation on two alternative frequencies with bearing indication and full control from points as remote as 20 miles.

Note on a Short-Range Radio Position-Finding System Using Modulated Continuous Waves. R. F. Cleaver. *Electrical Communication*, Vol. 25, No. 4, December, 1948, pp. 363–372, illus., diagrs., figs. 1 reference.

A position-finding system by which the polar coordinates of any suitably equipped aircraft can be displayed on a cathode-ray oscillograph at a single base station. Continuous transmissions are used to measure range by the phase comparison of a ground transmitted signal and the response-transmission signal from the aircraft. Azimuth is measured by a VHF automatic direction finder and is indicated without ambiguity. The probable error in measurements of ranges up to 100 nautical miles should be less than 1 mile when the air-borne communication equipment is designed for high phase-shift stability at the modulation frequency of 809 cycles per sec. This system requires only comparatively minor modification of conventional air-borne communication equipment and gives a service that is equivalent to that of a group of direction-finding stations arranged for triangulation.

An Omnidirectional, Vertically Polarized, Four Element Antenna Array. R. S. Rettie. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 10, October, 1948, pp. 457–463, diagr., figs. 3 references.

Four elements stacked vertically, each of which is half-wave radiator in the form of a cylinder and surrounds a mounting pipe, give a gain of about 4 db. over that obtained with a half-wave dipole antenna. The vertical antenna can be operated over a 10 per cent frequenccy band entered on 223 mc.



Why Feather-Weights lead in dependability

Unique construction and superior testing make FEATHER-WEIGHT Oil Coolers first choice for more and more modern aircraft.

Light, strong and compact because of patented aluminum alloy brazing of their thin all-aluminum sections, FEATHER-WEIGHTS offer the maximum weight-strength combination.

Thoroughly tested in our wind tunnel laboratory, the largest, most modern in the aeronautical heat exchanger industry, FEATHER-WEIGHT performance is accurately predicted under actual flying conditions.

Inquiries concerning FEATHER-WEIGHT all-aluminum oil coolers are invited. CLIFFORD MANUFACTURING COMPANY, 573 GROVE STREET, WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Chicago, Detroit, and Los Angeles.

CLIFFORD

HYDRON Metal Bellows

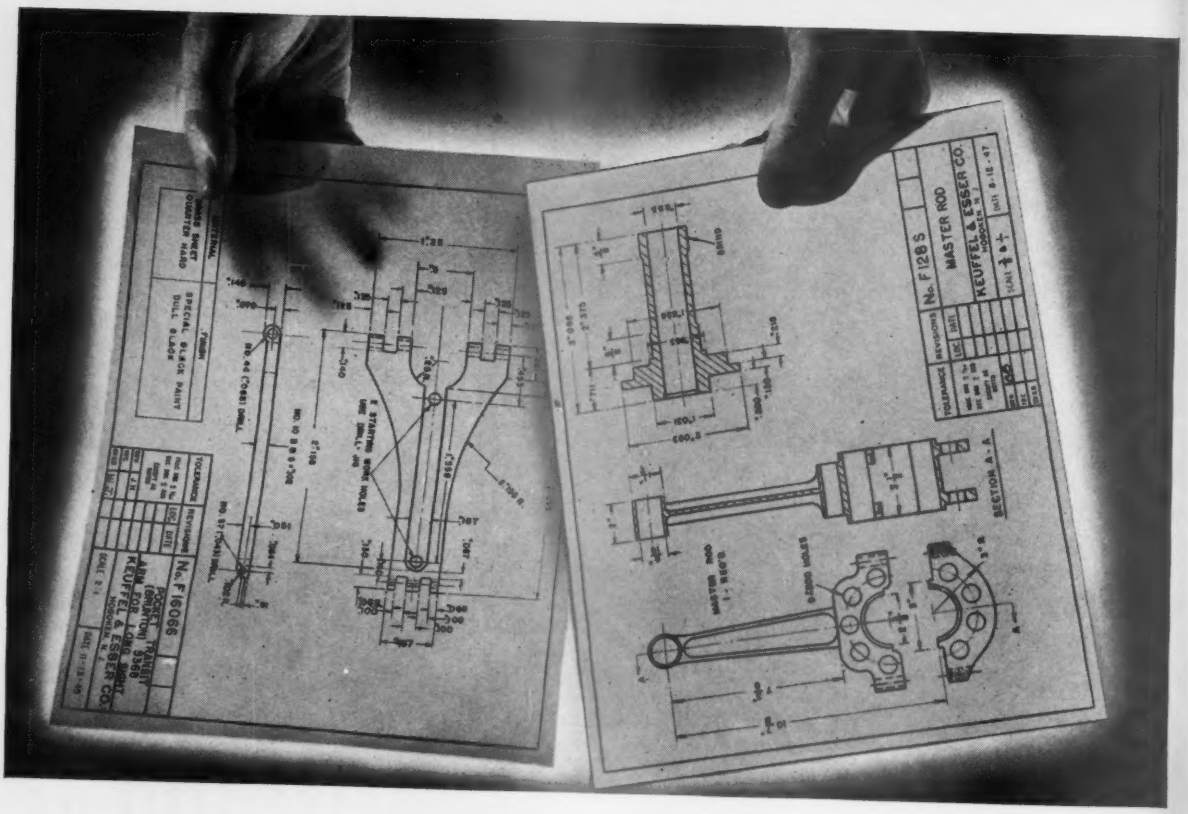
ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

K+E

partners

For 82 years K&E equipment and materials have been



ONLY HELIOS* DRY DEVELOPING MATERIALS GIVE YOU:

K&E QUALITY. Trusted by draftsmen and engineers for 82 years.

K&E DEPENDABILITY. Your best assurance of consistent results in making positive line prints.

Only when you use dependable materials can you get consistent results in making positive line prints.

To be sure of absolute K&E standards in the color-forming components required for these dry diazo products, we established a new plant where we manufacture HELIOS materials exclusively. We not only control and make the finished materials, but actually manufacture, from the raw materials, the image-forming chemical components as well. Thus HELIOS papers, cloths and films are the product of 82 years of K&E experience and K&E insistence on quality first.

HELIOS dry developed materials cover a wide field of reproduction needs. They consist of opaque papers (black, blue and maroon line) and opaque cloth for working prints, besides transparent papers and cloth and clear and matte films, for intermediate originals (to use instead of originals).

in creating . . .

partners of the draftsman, the engineer and the scientist in shaping the modern world

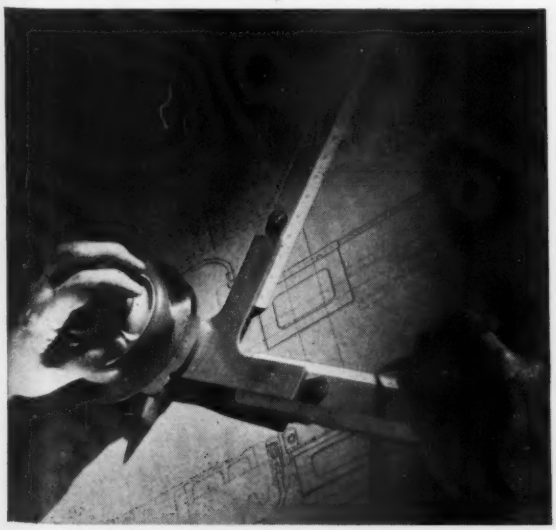
For samples and full information about the HELIOS line and what it can do for you, ask any K&E Dealer or Branch or write us here in Hoboken, N. J.

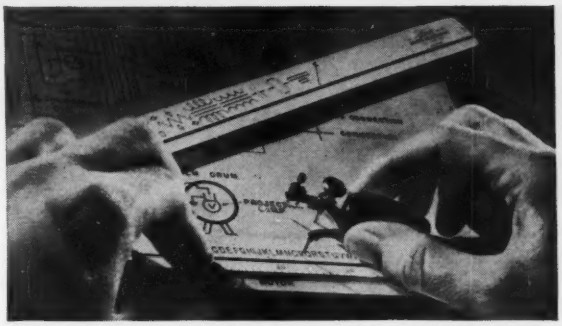
PARAGON* DRAFTING MACHINES TAKE WASTE MOTION OUT OF DRAWING

The PARAGON Drafting Machine combines T-Square, triangles, protractor and scales, all in one single unit, controlled entirely by one hand. The scales glide into any position on the board. The lightest touch rotates them to the angle desired. You can draw all lines to exact length.

The design of the PARAGON Drafting Machine assures permanent accuracy. The open center arm construction makes it practically impossible to disturb the band tension, which is properly set at the factory and needs no further adjustment.

Let your K&E Dealer or Branch demonstrate this machine or write for full description to Keuffel & Esser Co., Hoboken, N. J.





LEROY* LETTERING AND SYMBOL DRAWING IS UNIFORM AND QUICK

LEROY lettering and symbol drawing need no special skill or training. LEROY equipment offers a wide variety of alphabets and sizes, including Regular Gothic, Reversed, Condensed, Extended and Outline Gothic, Cheltenham, Greek, Isometric alphabets and ellipses, Electrical, Map and Welding symbols.

K&E can make special LEROY templates with your own words, phrases, designs, symbols or trade marks.

Ask your K&E Dealer or any K&E Branch for a demonstration or write to K&E, Hoboken, N. J. for the LEROY Booklet.

*Trade Mark®

K+E

Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes.

KEUFFEL & ESSER CO.

EST. 1867

NEW YORK • HOBOKEN, N. J.

CHICAGO • ST. LOUIS • DETROIT • SAN FRANCISCO

LOS ANGELES • MONTREAL

Engineering Study of Factors Affecting the Choice of Frequencies of DME. *International Civil Aviation Organization, Circular No. 7-A N/6,* July, 1948. 31 pp.

German Sonne Navigational Aid Radio Station. E. N. Dingley, Jr. *Combined Intelligence Objectives Sub-Committee, Item No. 1, File, No. 12–8,* December 14, 1944. 4 pp. British Information Services, New York. $0.20. Description of antenna tower and bombed-out installation at Bresles, near Beauvais, France.

A New Frequency Modulated Radio Sonde (Über eine neue Frequenzradiosonde). Ernst Menzer and Karl Sittel. *U.S., Field Information Agency, Technical, Final Report No. 1175,* July 21, 1947. 7 pp., illus. 4 references. (In German.) British Information Services, New York. $0.55.

Design, construction, calibration, and performance of a frequency modulation temperature-sensitive radiosonde, similar to the instrument developed in Finland by Vilho Väisälä. The sensitive element is a thin layer of a ceramic containing titanium oxide, on each side of which a silver coating has been fired. Since the dielectric constant of the ceramic is a linear function of temperature, the sensing element can function as a variable condenser. Two fixed reference condensers and the element are connected in series and coupled to the anode circuit of the transmitter. The meteorological data are thus transmitted as a function of wave length. Ascents were made to measure the relative topography of the 800- to 500-, the 500- to 225; and the 225- to 96-millibar levels. All points obtained from readings taken with an instrument in which temperature-compensated fixed capacitances were used fell within the allowable tolerance limits. At the highest level 80 per cent of the points were within these limits. The instrument can be modified to transmit pressure and humidity data.

Considerations in the Design of a Universal Beacon System. Ludlow B. Hallman, Jr. *Institute of Radio Engineers, Proceedings,* Vol. 36, No. 12, December, 1948, *Waves and Electrons Section,* pp. 1526—1529, diagrs. 3 references.

Specifications for a proposed universal radar-beacon system. It has been shown that air-borne transponder beacons are capable of performing so many essential functions that the problem has become one of deciding how many functions can be accomplished by a single beacon or of deciding how many beacons must be carried in a single aircraft to accomplish essential functions. All air-to-ground and ground-to-air intelligence is of two fundamental types: that pertaining to the air traffic control system and that pertaining to the navigation of the aircraft. The beacon system should be required to handle only those items of intelligence fundamental to the air traffic control system. These are: aircraft range, azimuth, altitude, and identity; and information transmitted and received automatically over private-line communication channels.

Evaluation of Transmission Efficiency According to Hartley's Expression of Information Content. A. G. Clavier. *Electrical Communication,* Vol. 25, No. 4, December, 1948, pp. 414–420, tables. 6 references.

Harmonic and Step Response of Simple Networks. R. G. Manley. *Aircraft Engineering,* Vol. 20, No. 237, November, 1948, pp. 344, 345, figs.

An analysis of the main features of the harmonic response and the step response of simple networks to show the relation of the two types of response and the method of deriving the response-ratio curves one from the other. Harmonic- and step-response analysis is applied to simple mechanical and electrical networks used in control systems.

Automatic Calibrator for Producing Equi-Step Potentials. *U.S., National Bureau of Standards, Technical News Bulletin,* Vol. 32, No. 12, December, 1948, pp. 146, 147, illus., diagr.

Drag Cut with Plastic Antenna Housings. Robert McLarren. *Aviation Week,* Vol. 49, No. 22, November 29, 1948, pp. 18, 20, 21, 24, illus., diagrs.

Drag reduction in high-speed aircraft has dictated the relocation of radio and radar antennas to enclosures within the aircraft streamlines. The increasing use of the higher frequencies has permitted the use of smaller antennas, but the susceptibility of these frequencies to distortion and reflection by an antenna housing have posed additional problems. Making the enclosures of plastic sandwich material with a low-density constant-thickness core neutralizes unwanted reflections, and graduation of the thickness of the enclosure wall minimizes the limitations imposed on design by the critical incidence angle. High-strength materials are under development which will withstand the friction heating caused by high speeds, will resist erosion, and will possess lower dielectric constants and loss factors.

Trends in Military Electronic-Equipment Design. Norman H. Young. *Electrical Communication,* Vol. 25, No. 4, December, 1948, pp. 334–336, illus.

The Electronic Principles of Digital Computers. Andrew D. Booth. *The Electronics Forum,* No. 11, September, 1948, pp. 5–25, diagrs., figs.

Speeding Radio Repair. Howard Mehr. *Aviation Maintenance & Operations,* Vol. 2, No. 1, December, 1948, pp. 38, 39, illus. Practice of Atlantic Aviation Corp., Teterboro, N.J.

Stratovision. Hugh Harvey. *Shell Aviation News,* No. 25, November, 1948, pp. 14–17, illus., diagr., figs.

A New, Versatile Camera for the Cathode-Ray Oscillograph; The Du Mont Type 314 Oscillograph-Record Camera (Fairchild). H. P. Mansberg. *The Oscillographer,* Vol. 10, No. 4, October-December, 1948, pp. 1–15, figs. 5 references.

Engineering Practices (49)

The Status of High-Speed Digital Computing Systems. Harry D. Huskey. *Mechanical Engineering,* Vol. 70, No. 12, December, 1948, pp. 975–978. 10 references.

The Bell Relay Computer. Franz L. Alt. *Instruments,* Vol. 21, No. 10, October, 1948, pp. 912, 913, illus.

Equipment

Pacific-Western Aircraft Actuators. *Western Gear Works, Bulletin No. 4811,* 1948. 36 pp., illus., diagrs. Dimensional data, performance charts, and specifications of 17 typical rotary-motion, linear-motion, and cable-drum actuators designed for use in aircraft.

ELECTRICAL (16)

A Polarized Relay as an Aircraft Control Element. Royce E. Johnson and Frank A. Glassow. *American Institute of Electrical Engineers, Middle Eastern District Meeting, Washington, October 5–7, 1948, Preprint.* 7 pp., illus., diagrs., figs. 9 references.

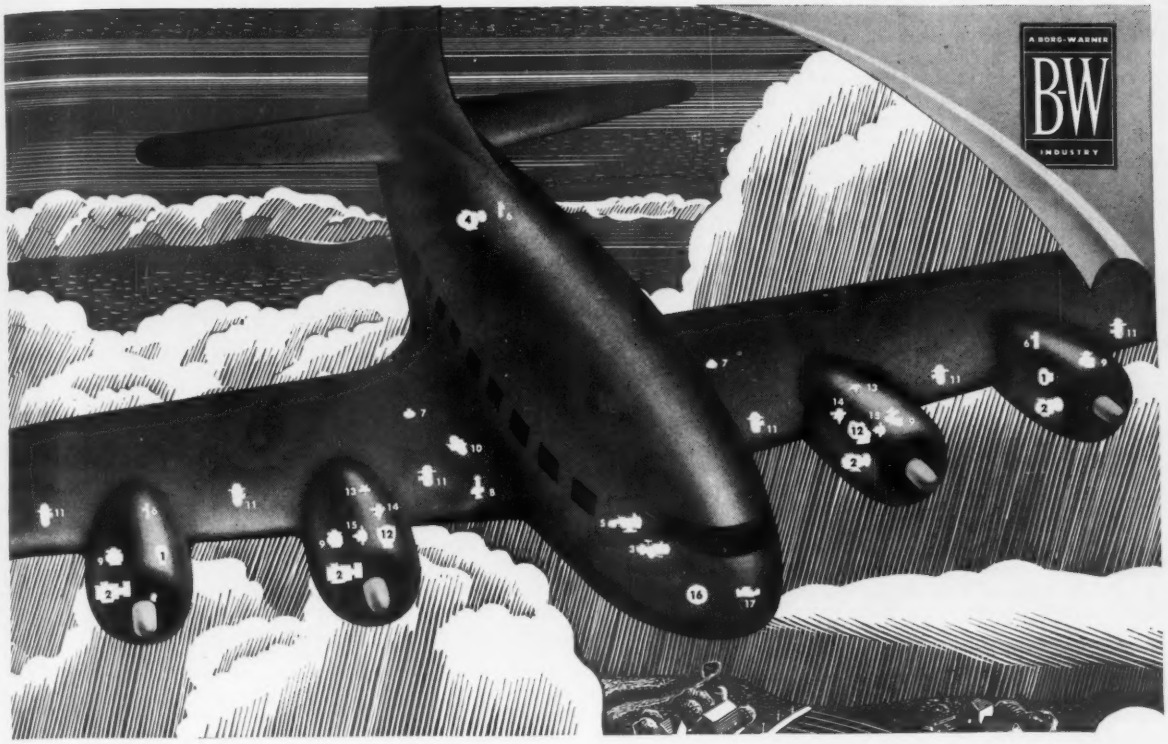
The relay is essentially a magnetic bridge. Symmetrical pole pieces cause the magnetic flux to pass through two identical air gaps. An armature extends between the midpoints of the two air gaps between symmetrical pole pieces of a permanent magnet. The armature corresponds to the galvanometer in a Wheatstone bridge circuit. Any difference in the magnetic potential between the gaps induced by a relay coil causes a flux to pass through the armature and produce a transverse force at its ends. A torsional spring supplies the restoring force. The relay is light and compact, can operate on an input of 40 microwatts, has a high overload factor, and is relatively insensitive to vibration. It was developed for the remote positioning of actuators in aircraft and can be used as a detecting element in control systems that employ a resistance bridge or other differential circuits as sensing element.

Aircraft Reverse Current Cutout. J. M. Marzolf. *Electrical Engineering,* Vol. 67, No. 12, December, 1948, p. 1183, diagrs. (Summary of a paper: Proposed Circuit for Aircraft Reverse-Current Cutout.)

A rotating permanent-magnet contactor is positioned by the relative strength of control magnetic fields produced by the battery and by the generator voltages. A cutout designed on this principle should be practically independent of temperature, altitude, and terminal voltage.

The Reverse Blowout Effect. Gary J. Himler and George I. Cohn. *Electrical Engineering,* Vol. 67, No. 12, December, 1948. pp. 1148–1152, illus., diagrs., figs. 5 references.

A laboratory apparatus to demonstrate the movement of a d.c. arc under the influence of an external magnetic field under simulated high-altitude atmospheric conditions. The bell-jar housing could be evacuated to a pressure of less than 1 cm. of mercury. As the pressure was reduced the velocity of travel of the arc decreased rapidly until, at critical pressure, the arc stopped moving and became a diffuse discharge. When the pressure was further reduced, the arc began to travel again but in a direction opposite to that in which it traveled at atmospheric pressure. This reversal is assumed to be caused by the increased mean free path of the electrons, which causes the formation of a new cathode spot in a direction contrary to that dictated by the external magnetic field.



Here are the 36 places on transport planes where Pesco PRECISION Equipment is used

Ever since manual operation of aircraft mechanisms became inadequate, Pesco has been specializing in building fuel and hydraulic equipment for America's commercial and military planes.

From the days of the first hydraulic pumps to today, when you will find Pesco equipment in 36 places on our large air liners, the design and construction of this equipment has been guided by the exacting requirements of the aircraft industry. Because plane performance and human lives have been at stake, there has been no compromise with top quality and performance.

That's why Pesco developed "Pressure Loading" for hydraulic pumps, an exclusive patented feature that automatically compensates for wear and maintains highest operating efficiencies over a wide range of temperatures and altitudes. That's why Pesco designs and builds its own electric motors . . . so that all electric motor-driven units are an integral part of the hydraulic or fuel unit, insuring top operating efficiency. That's why, today, America's leading builders of jet engines have *standardized exclusively* on Pesco high-pressure fuel pumps.

Take advantage of this engineering skill and "know-how". All the facilities of Pesco . . . the largest manufacturers of specialized aircraft fuel and hydraulics in the world are at your service.

KEY TO THE Pesco Precision Equipment indicated above:

1. Engine-driven hydraulic pump.
2. Propeller feathering pump.
3. Oil transfer pump.
4. Surface control booster pump.
5. Electric motor-driven hydraulic pump.
6. Hydraulic pressure relief valves.
7. Hydraulic flow equalizer.
8. Pressure reducing valve.
9. Engine-driven fuel pump.
10. Motor drive fuel transfer pump.
11. Fuel Booster pump.
12. Engine-driven vacuum pump.
13. Oil separator.
14. Suction relief valve.
15. Air pressure relief valve.
16. Electric Motor for Cabin ventilator.
17. Cabin heater fuel pumps.

Pesco PRODUCTS DIVISION
BORG-WARNER CORPORATION
11610 Euclid Ave. · Cleveland 6, Ohio
MANUFACTURERS OF BW SUPERCHARGERS

Crimping Cable Ferrules; Pneumatic Machine Developed for Work on the Bristol Brabazon Services. *Aircraft Production*, Vol. 12, No. 122, December, 1948, p. 412, illus., diagr.

The Transductor, D.C. Pre-Saturated Reactor; With Special Reference to Transductor Control of Rectifiers. Uno Lamm. 2nd Ed. *Acta Polytechnica* (Stockholm), No. 17 (*Electrical Engineering Series*, Vol. 1, No. 5), 1948. 215 pp., diagrs., figs. 62 references. Sw. Kr. 15.

Contents: Some Terms and Definitions. Symbols. Part 1, Survey of the Fundamental Mode of Operation and Application of the Transductor. Part 2, Similarity Laws for Transductors. Part 3, Short Survey of Published Theoretical Studies. Part 4, Fundamental Conceptions of New Theory for Transductor-Controlled Rectifiers. Part 5, The Real Transductor with Two-Zone Magnetisation Curve Under Stationary Conditions. Part 6, The Transductor with an Arbitrary Magnetisation Curve Under Stationary Conditions. Part 7, Fundamental Principles of the Transductor Under Dynamic Conditions. Part 8, Measurements. Bibliography.

"AN" Connectors for Power, Signal and Control Circuits in Aircraft and Electronic Equipment. *American Phenolic Corporation, Amphenol Catalog No. A-1*, October, 1948. 74 pp., illus., diagrs.

HYDRAULIC & PNEUMATIC (20)

Air Force Requirements for a Less Flammable Hydraulic Fluid. E. M. Glass. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 23, December 1, 1948, pp. 19–22.

A discussion of tentative minimum requirements on which will be based an experimental Air Force Specification for a less flammable hydraulic fluid. The new specification will be in accord with the performance requirements of AN-0-366 and will incorporate all the flammability tests of the AMS 3150, with the exception of the wick tests.

Hydraulic System Testing. Leo M. Chattler. *Product Engineering*, Vol. 19, No. 12, December, 1948, pp. 119–122, illus., diagrs., figs.

Hydraulic system analysis by recording instantaneous transient pressures occurring within any of the system's components. The pressure pickup unit is a thin-walled cylinder that distends with line-pressure surges to stretch a surrounding coil of resistance wire. Resistance increases with stretch and is proportional to variations in line pressure. The signal produced, when amplified and fed into a cathode-ray oscilloscope, describes pressure variations in the system by plots on the screen. This equipment is designed to measure pressures in the laboratory, in the field, and in aircraft at altitudes to 30,000 ft. with a capacity between vacuum and 15,000 lbs. per sq.in. Static and transient pressure variations to 20,000 times per sec. are described at low or high tracing speeds. Information regarding transient pressures will enable designers to work with appreciably smaller safety factors and can result in a considerable overall weight reduction.

Flight Operating Problems (31)

CLIMATIZATION

Cold Weather Flying. Fred G. Powell. *Skyways*, Vol. 8, No. 1, January, 1949, pp. 33–35, 52–55, illus.

ICE PREVENTION & REMOVAL

An Analysis of the Dissipation of Heat in Conditions of Icing From a Section of the Wing of the C-46 Airplane. J. K. Hardy. *U.S., N.A.C.A., Report No. 831*, 1945. 10 pp., figs. 14 references. U.S. Govt. Printing Office, Washington. $0.15.

PILOTING TECHNIQUE

Do's and Don'ts on Mountain Flying. Bill Woods. *The Air Traveler*, Vol. 3, No. 19, November, 1948, pp. 10, 14, illus.

Flight Safety & Rescue (15)

Aircraft Rescue and Fire Fighting Equipment for Aerodromes. *National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin No. 18 (2nd Revision)*, December, 1948. 22 pp., illus. $1.50. Recommended standards for the minimum amount of extinguishing agents and the corresponding personnel and fire-fighting equipment that should be immediately available at airports.

Fire Checks. *Aviation Maintenance & Operations*, Vol. 2, No. 1, December, 1948, pp. 28, 29. An analysis of origin of 200 personal airplane accidents caused by fires and a fire-prevention inspection check list.

Modern Shadrach Wears Suit of Laminated Aluminum Foil. *The Martin Star*, November, 1948, p. 2, illus.

A lightweight protective suit made of aluminum foil laminated to a cotton backing which was designed by the Air Materiel Command to protect fire fighters. It reflects heat and will withstand high temperatures but is not intended to be worn into the flames.

What Price Insurance? E. F. Peacock. *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, pp. 31, 32, illus. The cost of aircraft insurance in Canada and the factors used to establish the rates for ground, flight, hull, and liability insurance on commercial and privately owned land-based and water-based aircraft.

Fuels & Lubricants (12)

The Oxidation, Ignition, and Detonation of Fuel Vapors and Gases. VII—The Oxidation of Pentane in Varying Concentration in Air at Temperatures Rising to 700°C. and the Effect of Iron Carbonyl on Reaction Velocity. R. O. King. *Canadian Journal of Research, Section F, Technology*, Vol. 26, No. 10, October, 1948, pp. 426–440, figs. 5 references.

Results for the oxidation in reaction chamber No. 10 of pentane mixed with air, with mixture strength varied from 25 per cent weak to 100 per cent rich. Oxidations were carried out with and without additions of iron carbonyl to the pentane. The experiments were made mainly to find a rational explanation for the antiknock property of rich fuel-air mixtures. The experimental results for undoped mixtures show that, at temperatures approaching those of the end gas in an engine, reaction velocity increases by 100 per cent on increasing mixture strength over the range mentioned above and by 100 per cent on increasing temperature from 600° to 650°C. Similar increases in reaction velocity with rise of temperature and with increase of mixture strength were obtained for the doped mixtures over the high-temperature range but at temperatures 150°C. lower than for undoped mixtures. The characteristics of the experimental results confirm the conclusion that the oxidation of pentane in the conditions of the experiments is a heterogeneous reaction.

New Knock Rating Near for Aviation Fuel. Robert McLarren. *Aviation Week*, Vol. 49, No. 23, December 6, 1948, pp. 24, 25, figs. Review of the history of the octane rating of fuels and the rating problems presented by high-octane fuels, and an account of the development of a detonation index based on a leaded blend of triptane and normal heptane.

Deutsche Versuchsanstalt für Luftfahrt (D.V.L.), Institut für Betriebstofforschung: Interrogation of Evacuated Personnel at Strass Near Neuberg, Germany. C. C. Chaffee, W. F. Faragher, and W. H. Thomas. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 119, Item No. 30.* 38 pp. British Information Services, New York. $1.15.

A discussion of German aircraft fuels, their manufacture, specifications, engine testing, and gum and lead stability; the analytical estimation of tetraethyl of lead; and ethylene dibromide and antiknock additives. Contains technical data, specifications, and code names of diesel and safety fuels, fuels for jet engines and flying bombs; a résumé of D.V.L. research on combustion; and descriptions of aviation lubricants and greases.

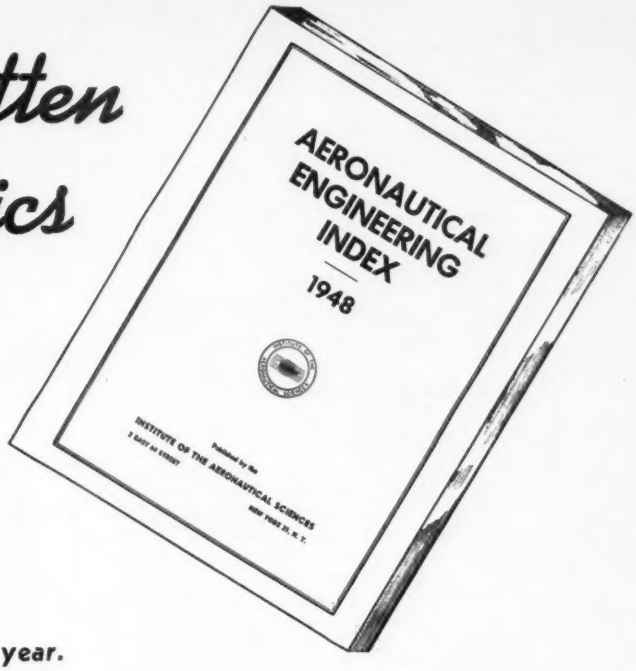
Oil Re-Use Offers Big Cost Saving; Re-Refining Procedures of the Air Force and Airlines. *Aviation Week*, Vol. 49, No. 23, December 6, 1948, pp. 27–29, illus.

Gliders (35)

Interference Between a Tug and a Glider. L. L. Th. Huls. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, p. 360, figs. 2 references.

Drag coefficients of a Gövier sailplane determined from free- and towed-flight data showed that the two forces measured were not suitable for determining the drag of the glider because of the difficulty in accounting accurately for interference effects. The measured tow force was considerably increased by change in the down-wash angle caused by the height of the glider relative to the tug, and the formula for the theoretical effect of down-wash was

What was written on Aeronautics in 1948?



Here are the answers— in one handy reference guide. Over 5,000 abstracts and listings of important technical articles and books published during the year.

Each month, over 800 periodicals, reports, books, and house organs pertaining to the aeronautical sciences are screened, listed, and digested by the Institute's editorial and library staffs. The AERONAUTICAL ENGINEERING INDEX is the end-product of this year-long effort. In this concisely indexed volume will be found listings and abstracts of those items deemed of interest and importance to engineers and scientists in all branches of aeronautics.

INDEX FOR 1947

The first edition of the AERONAUTICAL ENGINEERING INDEX, published last year, contained the listings and abstracts of items published during 1947. A limited number of these first volumes are still available.

SPECIAL COMBINATION OFFER

While the supply lasts, individuals and libraries ordering the 1948 INDEX may also complete their reference files and obtain the 1947 INDEX at a premium.

Use this Coupon for Combination Offer or Individual Copies of Indexes

Preprint Department
Institute of the Aeronautical Sciences
2 E. 64th St., New York 21, N.Y.

Please send postpaid copies of the Aeronautical Engineering Index, for which check for $_____ is enclosed.

- ☐ 1948 Index (Price $5.00; $3.00 to I.A.S. Members)
- ☐ 1947 Index (Price $5.00; $3.00 to I.A.S. Members)
- ☐ Combination—1948 & 1947 Indexes ($7.50; $5.00 to I.A.S. Members)

Name_____

Address_____

City_____ Zone_____ State_____

inadequate as a correction factor because of its omission of a factor representing the effect of the viscosity of air.

The Lunak L-107; Another Czechoslovak High-Performance Sailplane. Jacques Cochemé. *Sailplane and Glider*, Vol. 16, No. 12, December, 1948, pp. 4, 5, illus., diagr.

Take Another Look at the Small Sailplane. Irving Prue. *Soaring*, Vol. 12, No. 11–12, November–December, 1948, pp. 8, 9, 18, illus., diagr. Advantages of the small sailplane and improvements incorporated in the Prue 215.

The Schweizer "1-23." Paul Schweizer and Ernest Schweizer. *Soaring*, Vol. 12, No. 9-10, September-October, 1948, pp. 8–10, illus., fig.

The Sohaj (ZLIN-25); The Latest High-Performance Sailplane Now Flying in Czechoslovakia. T. Rex Young. *Sailplane and Glider*, Vol. 16, No. 11, November, 1948, pp. 5–7, illus.

Guided Missiles (1)

Base Pressures at Supersonic Velocities. Freeman K. Hill and Ralph A. Alpher. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3, March, 1949, pp. 153–160, diagr., figs. 8 references.

Base pressures were measured directly in free flight on missiles consisting of a 14-cal. ogival nose adjoining tangentially a cylindrical body of 4-in. diameter at Mach Numbers $0.8 < M < 2.5$. The base-pressure coefficient was nearly constant for $1.2 < M < 1.6$ and then decreased in absolute magnitude with increasing Mach Number. Base-pressure coefficients measured in wind-tunnel tests made with one of the free-flight and other models were significantly smaller in absolute value at $M = 1.73$ than those obtained in flight tests. The wind-tunnel measurements were all made at Reynolds Numbers considerably lower than those of the flight tests, which, at $M = 1.6$, were between $R = 2 \times 10^7$ and $R = 1 \times 10^8$. Thus at supersonic velocities scale effect on base pressure may be significant. Pressure distribution over the base was essentially constant. Base pressure displayed no dependence on body length and only a slight dependence on angle of attack. Graphs show functional dependence of the base pressure on Mach Number, Reynolds Number, body length, position on the base, and body angle of attack.

Homing and Navigational Courses of Automatic Target-Seeking Devices. Luke Chia-Liu Yuan. *Journal of Applied Physics*, Vol. 19, No. 12, December, 1948, pp. 1122–1128, figs.

A graphic and mathematical analysis of homing and navigational courses for automatic target-seeking devices that will intercept the target in the shortest time. A homing course, one in which the velocity of the seeker is at all times directed toward the target, is impractical if the speed of the seeker is more than twice that of the target, because the radius of curvature of the course becomes infinitely small. A more practical path for a target-seeking device to follow is an approximation of a navigational (constant-bearing) course. As discrepancies develop in the sighted bearing, the sighting device is turned through an angle equal to the error, while simultaneously the seeker is turned in the same sense through an angle that is a constant fraction of the discrepancy. Navigation courses with various navigational correction constants ranging from one-half to one-fifth are plotted for straight and for circular target courses. A correction factor of one-third for a seeker-to-target speed ratio of 4 gives a close approximation, without hunting, to a true navigational course.

Influence of Earth's Gravitation on the Requirements of the Vertical Trajectory Rocket, With Special Reference to Escape. John Paul Sellers, Jr. *American Rocket Society, Journal*, No. 75, September-December, 1948, pp. 126–142, diagrs., figs. 10 references.

An analysis of the fundamental dynamics of the gravitational relation between bodies yields an expression for the gravitational velocity of a body—i.e., the velocity a body must have in order to escape the earth's gravitational attraction and to coast to given altitude with a minimum expenditure of energy. An ideal long-range rocket would have this velocity as its initial velocity. An actual rocket would have a zero initial velocity and would require expenditure of energy during the initial leg of its trajectory for a time sufficient for its acceleration to gravitational velocity of escape. Corrections are obtained for this additional energy and the difference between sea level and the point on the trajectory at which escape velocity is actually attained. The analysis takes into account the variation of the earth's gravitational attraction upon the rocket during its powered and during its coasting flight. Two numerical examples apply the analysis to the calculation of mass ratio and trajectory in actual problems.

Investigation of Stassfurter Rundfunk Stassfurt. R. E. Burns, R. G. Friend, and others, *Combined Intelligence Objectives Sub-Committee, Item Nos. 1, 7, File No. 32–88*, May 10, 1945. 7 pp. British Information Services, New York. $0.35. Manufactured radio and wire-control systems for the HS293 and FX guided missiles.

Will Missiles Replace Fighters? R. G. Naugle. *Flying*, Vol. 44, No. 1, January, 1949, pp. 20, 21, 72, 73, illus.

Guided Missile Instruction at Fort Bliss, Texas. Lawrence W. Byers. *Antiaircraft Journal*, Vol. 91, No. 6, November-December, 1948, pp. 35, 36, illus.

Instruments, Aircraft (9)

Pitot Pressures in Moist Air. G. I. Taylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2248*, January 29, 1945. 5 pp., figs. British Information Services, New York. $0.45.

A pressure-volume diagram for the adiabatic expansion of moist air can be used to find the correction to be applied to pitot pressure readings when expansion of the air has lowered the temperature and caused the condensation of water vapor. The relative dimensions of the droplets and the pitot tube determine whether or not the droplets will strike the back of the tube and thus not contribute to the observed pressure. This factor may introduce an uncertainty of order 12 per cent in the calculation of water-vapor content from pitot-pressure measurements. The analysis can also be used to determine the degree of supersaturation and the increased resistance of a body caused by condensation.

Calibration of Accelerometers. Samuel Levy, Albert E. McPherson, and Edward V. Hobbs. *U.S., National Bureau of Standards, Journal of Research*, Vol. 41, No. 5, November, 1948, pp. 359–369, illus., diagrs., figs. Available also as *Research Paper No. RP1930*. U.S. Govt. Printing Office, Washington. $0.10.

Three calibrators were developed to provide a convenient means for calibrating lightweight accelerometers of the types used for measuring accelerations on airplanes in flight. The first calibrator is a shaking table having a sinusoidal motion with frequencies of 20 to 110 cycles per sec. and accelerations up to 80 gravity; the second is a portable calibrator producing a known pulse of acceleration with a peak value between 1 and 20 gravity; and the third is a centrifuge that develops a maximum steady acceleration of about 1,000 gravity.

The Zero Reader (Sperry) Miracle Navigator. Charles A. Macatee. *Flying*, Vol. 44, No. 1, January, 1949, pp. 19, 59, 60, diagr.

Modern Instrumentation by Kollsman. *Plane Facts*, Vol. 5, No. 11, November, 1948, pp. 11, 12, 32, illus.

A Comparison of Small and Medium Power Electric Servomotors. Robert S. Edwards. *Instruments*, Vol. 21, No. 12, December, 1948, pp. 1137–1141, figs.

Characteristics of a Magnetic Compass. II. A. Kingsnorth. *The Technical Instructor*, Vol. 3, No. 11, November, 1948, pp. 9–16, diagrs. Sources of error, compensating design, and procedures for testing and operation.

Accelerometer Calibrators. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 32, No. 12, December, 1948, pp. 142–144, illus. 2 references.

Navigator's Shortcut. *Flying*, Vol. 44, No. 1, January, 1949, illus. Mattern Course and Mile Gauge.

Altimeter Settings; Arguments Favouring Introduction of Standard Setting (QNH). *Flight*, Vol. 54, No. 2086, December 16, 1948, pp. 728, 729.

A comparison of the advantages and disadvantages of QFE, QFF, QFE (Alt.), regional QFF, and QNH altimeter settings. The adoption of a standard setting would eliminate unnecessary adjustment and the possibility of confusion or error in selecting a setting. Its adoption would simplify traffic separation and navigation and expedite cross-country air traffic.

Lighter-Than-Air (40)

Largest Military Non-Rigid Airship (Goodyear Type N). *Plane Facts*, Vol. 5, No. 11, November, 1948, pp. 24, 25, illus.

Bendix Products

AIRCRAFT FUEL METERING SYSTEMS

Bendix* Direct Fuel Injection Pump.
Stromberg* Injection Carburetor for large engines.
Bendix* Speed-Density Fuel Metering Unit.
Stromberg* Float Type Carburetor.
F9F
F-84
F80C
Stromberg* Injection Carburetor for personal planes.
Regulator for Bendix Water Injection System.
Bendix* Fuel Metering Unit for jet engines.

BENDIX FUEL METERING CONTROLS

Performance-Proved on Leading Jets

In two years of flight use, Bendix Fuel Metering Controls have set a remarkable record for *efficient, versatile,* and *dependable* operation. Today they are continuing to set the pace on such planes as the F9F, the F84, and the F80C.

Efficient: New use of altitude compensation . . . practically isochronous in operation . . . constant air-fuel ratio and temperature for acceleration.

Versatile: Work equally well with gasoline or kerosene . . . With or without water injection . . . Adaptable to various exhaust nozzle areas . . . Can be modified to handle surge limitations.

Dependable: A record of dependability beyond all expectations—comparable to that of other Bendix Fuel Metering Equipment over the years.

*REG. U. S. PAT. OFF.

BENDIX PRODUCTS

DIVISION of Bendix AVIATION CORPORATION

SOUTH BEND 20, INDIANA

Machine Elements (14)

Report on Unification of Screw Thread Standards. *U.S. National Bureau of Standards, Technical Report No. 1315,* November, 1948. 24 pp., illus., figs.

An affirmation by the U.S., the United Kingdom, and Canada of the unification of screw-thread standards, proposed by the Interdepartmental Screw Thread Committee of the U.S., the British Standards Institution, the Canadian Standards Association, and the American Standards Association, specifies 60°-angle and a rounded root for screw threads. The crest of the external thread may be flat or rounded. The number of threads per inch for the various series of thread diameters and the limiting dimensions for three grades of fit have been agreed upon. Included are a photostatic copy of the Declaration of Accord; tables of basic dimensions of unified coarse- and fine-thread series; and limits of size for class 2A external threads and class 2B internal threads, both coarse and fine.

A Theoretical Discussion of Pitting Failures in Gears. R. Beeching and W. Nicholls. *Institution of Mechanical Engineers, Proceedings,* Vol. 158, No. 3, December, 1948, pp. 317–323, Communications, pp. 323–326, figs. 22 references.

Maintenance (25)

Maintenance in the Air. I. II. Hedley S. Crabtree. *The Aeroplane,* Vol. 75, Nos. 1954, 1955, November 19, 26, 1948, pp. 650–652; 678, 679; illus., diagr., figs.

I. As the size of aircraft is increased, the ground time required to accomplish maintenance schedules reduces the theoretical maximum utilization time of the aircraft. For large commercial aircraft to be operated economically, this ground time must be reduced. This could be accomplished at a small cost in pay load by designing aircraft so that a maximum portion of the maintenance schedules might be performed in the air. Utilization would be greatly increased if loading and refueling time were used for major repairs and if adjustments and subsequent checks and inspections were made during flight. **II.** Maintenance checks in the air will permit a theoretical maximum utilization rate of 20 hours per day on aircraft of at least 300,000 lbs. weight. Passages separate from passenger or freight accommodations, triplication of flying controls, and a centrally disposed engineers' control room would increase weight and limit such flight maintenance to aircraft of this minimum weight.

Aircraft Servicing. J. Norman and S. F. Wilkinson. *Royal Aeronautical Society, Journal,* Vol. 52, No. 455, November, 1948, pp. 753–758.

The adoption of scheduled aircraft maintenance programs that distribute the time spent in overhaul and inspection over the entire year makes possible a degree of aircraft utilization that could not have been attained when most major maintenance work was performed during a protracted annual overhaul. The maximum aircraft utilization and highest maintenance efficiency, however, require, in addition to scheduled maintenance and planned shop and inspection practice, a more comprehensive knowledge of the life span of individual airplane components. With this information, which could be supplied by standardized laboratory testing, each component of an assembly could be designed for a maximum life equal to the period between assembly overhauls. Thus, maintenance would be reduced to simply the removal and replacement of entire assemblies and subassemblies at predetermined times, and shop loads and parts requirements could be predicted with accuracy.

Correspondence: Maintenance Design Questions. W. J. Halland. *Royal Aeronautical Society, Journal,* Vol. 52, No. 455, November, 1948, pp. 764–766.

Design practices that contribute to unnecessary aircraft maintenance. Costs of maintenance would be reduced if periodic inspections were eliminated and each component were replaced at the end of its rated life.

DC-3 Feeder Line Conversion. Ralph E. Gilliam. *Airports and Air Carriers,* Vol. 14, No. 6, December, 1948, pp. 6–8, illus. Seat, baggage stowage, hand rail, and electronic equipment modified by Empire Airlines to adapt the DC-3 airplane for feeder-line service.

Aircraft Maintenance in the Netherlands. *Aircraft Engineering,* Vol. 20, No. 238, December, 1948, p. 367, illus. The work of Avio-Diepen N.V. Facilities, a brief history, and the scope of the light-aircraft maintenance, overhaul, and repair work of Avio-Diepen N.V. and the air-charter service of Aero-Holland N.V.

Prevent That Leak. W. R. Rhoads and Max Helzel. *Aviation Maintenance & Operations,* Vol. 2, No. 1, December, 1948, pp. 31-33, illus., diagr. Methods used by Lockheed Aircraft Service, Inc., to detect leaks, repair the seal, and replace the sealant compound inside integral fuel and lubricant tanks.

S.A.S. Maintenance Dry Dock for DC-6's Cuts Overhaul Time by 20%. *Shell Aviation News,* No. 125, November, 1948, p. 22, illus.

TEMCO Busy on Airlift Overhaul; Dallas Plant Currently Processes 50 C-54's. *Aviation Week,* Vol. 49, No. 25, December 20, 1948, p. 17, illus.

Super-Service for Private Planes. *Airports and Air Carriers,* Vol. 14, No. 6, December, 1948, pp. 15, 38, illus.

Boeing Service Guide, No. 15, December, 1948. 8 pp., illus., diagrs., figs. Contents: Cabin Altitude Conditioning. Current Requirements of Major Electrical Units. Revision to AC Power Distribution.

Boeing Service Guide, No. 13, October, 1948. 8 pp., illus., diagrs. Contents: Control System Friction. Model 377 Lubricants. Magneto Grounding Plug. Improper Procedures Cause Serious Damage to Nose Wheel Steering Mechanisms. General Rivet Information.

Douglas Service, Vol. 6, No. 12, December, 1948. 20 pp., diagrs.

Contents: Reversible Pitch Propellers—Description and Function of Curtiss Electric Installation, DC-6. Water Injection—Ground Check, DC-6. Speed Reduction in Turbulent Air, DC-6. Flexible Hose Identification, DC-6. Oxygen System—Description of Low-Pressure and Two High-Pressure Systems, DC-6. Nose Wheel Steering Shut-Off Valve—Method of Installing New Replacement Rings, DC-4. Elevator Trim Tab Jackshaft—New Close Tolerance Bearings, DC-6. Static Discharges—Maintaining Dischargers at Their Highest Efficiency, General. Advance Engineering Changes, DC-4, DC-6. Zero Wing Fuel Weight—Explanation and Application, DC-4. Torque Value Change, DC-6.

Management & Finance (45)

Plane Production Starts to Climb. I. *Aviation Week,* Vol. 49, No. 21, November 22, 1948, pp. 12, 13, illus. Report on Boeing (Wichita), Beech, Cessna, Convair, Ryan, and Douglas.

How Boeing Spreads its Work. *Aviation Week,* Vol. 49, No. 23, December 6, 1948, p. 18, diagrs. The allocation of subcontracts by the Boeing Airplane Company. Detail subcontract allocation s given for the B-50.

A National Wage-Scale? The Problems of Extending a One-Factory Wage-Assessment Scheme to Cover the Whole of British Industry. J. J. Gracie. *Aircraft Production,* Vol. 10, No. 10, No. 122, December, 1948, pp. 406, 407.

Materials (8)

METALS & ALLOYS

The Stress-Strain Characteristics of a Magnesium Alloy Beam. A. E. Johnson and D. C. Herbert. *Aircraft Engineering,* Vol. 20, No. 237, November, 1948, pp. 330–334, diagrs., figs.

A magnesium-alloy beam was subjected to 18 cycles of bending at room temperature under a uniform bending moment that in the initial cycle caused 0.1 per cent plastic strain in the outer fibers of the beam. Auxiliary compression and tensile tests were made on materials with no plastic deformation taken from near the neutral axis of the beam. The data obtained from strain gages at various fibers of the beam and from the auxiliary tests were used to interpret the state of stress and moments of resistance of the beam at successive cycles. In general, the calculated moments of resistance were less upon loading and greater upon unloading than the applied bending moments. Their difference varied from about 30 per cent in the initial cycle to about 4 per cent in the final cycle. These discrepancies are attributed to a difference in the elastic range and the course of the plastic portion of the deformation in the two types of test. Therefore, stress distribution data, upon which the design of structural magnesium-alloy beams (which may be subjected to bending stresses that produce plastic strain) may be based, cannot be directly ascer-

The KAMAN HELICOPTER

Lands Like a Feather

with Electrol Landing Gear Oleos

There are many new outstanding design features to be found in the Kaman Aircraft Corporation Helicopter—engineering advancements that provide easier response to the pilot's touch . . . greater maneuverability . . . increased versatility. Also, there's the use of Electrol Landing Gear Oleos to absorb the 'copter's descent energy so it *lands like a feather.*

Manufactured to Electrol's rigid standards of scientific accuracy, these specially designed Landing Gear Oleos fully meet the exacting requirements of helicopter operations. They are light in weight, easy to install, service and maintain.

Feel free to call upon Electrol's engineering staff whenever you need help in the solving of a problem involving the use of hydraulics. Your inquiry will receive our prompt attention.

•

Electrol

INCORPORATED

KINGSTON, NEW YORK

CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

FOR BETTER HYDRAULIC DEVICES

tained by bending tests and by auxiliary tensile and compression tests.

Magnesium Gains in Aero Industry. *Plane Facts*, Vol. 5, No. 11, November, 1948, pp. 16, 17, 29, 30, illus., diagr.

Magnesium Alloys: Their Corrosion Behavior. *The Magazine of Magnesium*, November, 1948, pp. 2–5, illus.

Development of Magnesium Applications at Wright-Patterson Air Force Base. Jay R. Burns. *The Magazine of Magnesium*, November, 1948, pp. 8–11, illus.

Effect of Fatigue on Tension-Impact Resistance. William H. Hoppmann, II. *American Society for Testing Materials, Bulletin*, No. 155, December, 1948, pp. 36–38, figs. 3 references.

Tension specimens were cut from a low-carbon steel plate in a known fatigue condition and subjected to impact tests at various velocities up to 120 ft. per sec. Graphs of energy and of total elongation as functions of impact velocity showed that the loss of impact resistance, caused by a given amount of fatigue, was larger at the higher impact velocities. Although the maximum fatigue stress tested, 28,000 lbs. per sq.in., was well below the yield stress of the specimens, a loss of as much as 30 per cent was recorded.

Methods of Testing Creep Resistant Alloys. Wilfred Francis Coxon. *Materials & Methods*, Vol. 28, No. 6, December, 1948, pp. 76–78, illus., figs.

The creep behavior of a typical metal. Creep can be measured by the elongation of the specimen when subjected for a specified period of time to the time yield stress, a stress approximately equivalent to a rate of creep of one millionth of an inch per inch per hour. It is also measured by the stress necessary to produce definite amounts of strain and ultimate rupture in specified times. During creep measurements, temperature must be kept constant because creep performance at one specified temperature cannot be predicted of other temperatures.

A Metallurgical Investigation of a Contour-Forged Disc of EME Alloy. E. E. Reynolds, J. W. Freeman, and A. E. White. *U.S., N.A.C.A., Technical Note No. 1534*, November, 1948. 30 pp., figs. 7 references.

Investigation of the properties of EME (19Cr-12Ni-3W-1Cb) alloy at room temperature and at 1,200°F. showed contour-forged discs for the gas-turbine rotors, prepared early in the development of the alloy, to have properties inferior to experimental bar stock. Since one prepared subsequently on the basis of more experience showed excellent properties at room temperature, particularly at the center of the disc, the poor properties are probably not typical but reflect an unfortunate choice of forging conditions.

Dutch Report on Different Subjects in the Steel and Metal Industry. D. v.d. Berg, J. E. de Graaf, H. J. Meerkamp van Embden, and C. H. Luiten. *Gt. Brit., British Intelligence Objectives Sub-Committee, Miscellaneous Report No. 79.* 49 pp. British Information Services, New York. $1.60. Reports on the inspection of 22 German plants which describe the technology and production methods used in the production of ferrous and nonferrous metals and alloys.

A Method of Calibrating Extensometers. W. C. Aber and F. M. Howell. *American Society for Testing Materials, Bulletin*, No. 155, December, 1948, pp. 33–35, illus., figs. 5 references.

A special calibration bar, the modulus of elasticity of which has been determined precisely, is stressed at a load well below its proportional limit, as in a tension or compression test. The strain-measuring device is mounted on the bar, and a load-strain curve is plotted. The deviation of this plot from the precise modulus line of the calibration bar shows the accuracy of the test instrument.

Low-Temperature Properties of 18-8 Stainless Steel. D. J. McAdam, G. W. Geiland, and Frances Jane Cromwell. *Steel Processing*, Vol. 34, No. 11, November, 1948, pp. 592–594, illus., figs.

NONMETALLIC MATERIALS

High-Temperature Ceramic Materials. A. L. Berger. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 23, December 1, 1948, pp. 13–18.

A survey of recent developments in high-temperature ceramic and metal-ceramic material. Materials and fabrication techniques under investigation include graphite and silicon carbide mixtures, fused alumina, and silicon carbides; oxides, borides, nitrides, and carbides; vapor phase impregnation of ceramic bodies; the capillary intrusion of prefired ceramics by molten metals; plaster of Paris and similar compounds that undergo endothermic chemical changes; and ternary and quaternary oxide systems that are completely miscible in the molten state. Materials are being sought which will prevent the flow of heat through the metal of turbine combustion chambers, tailcones and tailpipes and through the walls of rocket combustion chambers and nozzles of power plants under operating temperatures between 1,200° and 5,000°F. Ceramic coatings have already reduced the infrared emissivity of engine exhaust tailpipes from 80 to 90 per cent. Their further development anticipates coatings to prevent the war head of missiles from glowing and from absorbing heat. Similar coatings are sought which will prevent high-speed airfoils from absorbing the heat generated by their passage through the atmosphere. Twenty-seven metal-base compounds that have melting points between 3,810° and 7,390°F. are listed, and the physical and chemical properties of ten ceramic refractories are tabulated.

Pure Oxide Refractories Withstand High Temperatures. O. J. Whittemore, Jr. *Materials & Methods*, Vol. 28, No. 6, December, 1948, pp. 79–81, figs.

Physical properties of alumina, magnesia, zirconia, beryllia, and thoria. Typical commmercial formulations of these materials were tested to determine their porosity and density, volume stability, thermal conductivity coefficients, and failure temperatures.

Theories of Adhesion as Applied to the Adhesive Properties of High Polymers. Charles J. Seiler and A. D. McLaren. *American Society for Testing Materials, Bulletin*, No. 155, December, 1948, pp. 50–52. 25 references.

SANDWICH MATERIALS

Shear Flows in Multicell Sandwich Sections. Stanley U. Benscoter. *U.S., N.A.C.A., Technical Note No. 1749*, November, 1948. 28 pp., diagrs., figs. 5 references.

In order to develop the differential-difference equation for the relation between the load and the deflection of multicell sandwich sections, the various relations between cellular shear flows and cell twists that may actually exist are determined. Solutions are obtained for the distribution of shear flows required to preserve continuity of the warping displacements when the twist distribution among the cells is uniform; when the distribution from cell to cell is linear; and when there is a sine distribution, a characteristic distribution, and an arbitrary distribution. Symmetrical shear-flow distributions provide a resultant torque on the section but not resultant shear. Antisymmetrical distributions give neither a resultant shear nor a torque and are self-equilibrating. From the formulas developed for shear flows in pure torsion, a formula is derived for the torsion constant of a multicell sandwich section.

Meteorology (30)

Thermistors as Instruments of Thermometry and Anemometry. Wayne B. Hales. *American Meteorological Society, Bulletin*, Vol. 29, No. 10, December, 1948, pp. 494–499, diagrs., figs.

Thermistor beads are used as the sensitive elements for measuring temperature and wind speed. Their high resistance makes it unnecessary to correct for the resistance of leads or the change in their resistance due to temperature. Because of the high negative temperature coefficient of resistance of thermistor material, slight changes in ambient temperatures cause sufficient changes in the bead resistance to unbalance a bridge circuit and thereby activate a recording milliammeter. The instrument may be calibrated to read temperatures. If the change in resistance of a hot bead is caused by the wind, the milliammeter may be calibrated to read wind speed.

First Trials of the Schaefer-Langmuir Dry-Ice Cloud Seeding Technique in Hawii. Luna B. Leopold and Maurice H. Halstead. *American Meteorological Society, Bulletin*, Vol. 29, No. 10, December, 1948, pp. 525–534, illus., figs. 7 references.

Procedure and evaluation of results obtained in 15 tests totaling 54 seedings of cumulus clouds with dry ice. Appropriate conditions were selected to determine whether precipitation could be induced when supercooled water droplets were not present in the cloud and its temperature was above freezing. In twenty seedings, either rain or virga was observed, generally in less than 16 min. after seeding; in one case, 1.25 in. of rain fell from the seeded cloud. The thickness of the cloud displayed a significant correlation to subsequent presence or absence of precipitation. The results indicate tentatively that the seeding was a factor that influ-

enced the time of beginning and possibly the amount and the area of precipitation.

Second Partial Report on the Artificial Production of Precipitation, Cumuliform Clouds, Ohio, 1948. Richard D. Coons, Earl L. Jones, and Ross Gunn. *American Meteorological Society, Bulletin*, Vol. 29, No. 10, December, 1948, pp. 544–546, tables. 5 references.

Charts of Dielectric Constant or Refractive Index of the Troposphere. Albert W. Friend. *American Meteorological Society, Bulletin*, Vol. 29, No. 10, December, 1948, pp. 500–509, figs. 21 references.

An index chart and seven sector charts for conversion from radiosonde (RAOB) or similar tropospheric pressure (millibars), the temperature (°C.), and the water-vapor mixing ratio (grams per kilogram) to the dielectric constant or the radio-frequency index of refraction of the atmosphere

Atmospheric Tides in the Ionosphere. III—Lunar Tidal Variations at Canberra. IV—Studies of the Solar Tide, and the Location of the Regions Producing the Diurnal Magnetic Variations. D. F. Martyn. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 194, No. 1039, November 9, 1948, pp. 429–444; 445–463, figs. 6, 10 references.

Standing Wave. Harland Ross. *Soaring*, Vol. 12, No. 9–10, September-October, 1948, pp. 2–4, 13, illus., figs. Description of standing-wave formation observed in the vicinity of Bishop Airport, which is situated in the Owens Valley between the ranges of the Sierra Nevada Mountains.

Military Aviation (24)

Berlin Airlift. Geoffrey Dorman. *Canadian Aviation*, Vol. 21, No. 12, December, 1948, pp. 16, 17, 40, 42, 44, illus. Strategy, administration, operational statistics, and personalities.

Troubles of French Air Force. Boyd France. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, p. 32.

Special Air Navy Issue. *Aero Digest*, Vol. 57, No. 6, December, 1948. 74 pp., illus., diagrs.

Contents: Guided Missiles (for the War After Next?), D. V. Gallery. Naval Air Power, Arthur W. Radford. Aircraft vs. the Submarine, Charles B. Momsen. The Navy Takes to the Air, Owen Brewster. The Story of Patuxent, Apollo Soucek. Washington Information, Kendall K. Hoyt. Now—An Advance Arm of Air Power, John D. Price. Naval Aviation Training, John Walter Reeves, Jr. Fast Carrier Task Force, Ralph A. Ofstie. The Helicopter in Naval Service, Alexander Klemin. The Flying Admirals, Cy Caldwell. Ramjet Progress, Nathaniel F. Silsbee. The Air Marines, William J. Wallace. Problems That Won't Stay Licked, Charles A. Nicholson, II. Directory of United States Navy Planes, Ira F. Angstadt. Naval Aviation Supply, E. D. Foster.

The Impact of Air Power Upon History. Eugene M. Emme. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 3–13. 4 references.

Eighth Air Force Defensive Measures Against German Flak. *Antiaircraft Journal*. Vol. 91, No. 6, November-December, 1948, pp. 45–50, figs.

Airdrome Defense in the Arctic. R. E. Moore. *Antiaircraft Journal*, Vol. 91, No. 6, November-December, 1948, pp. 33, 34.

The Time Factor in War. Charles H. Anderson. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 66–73.

The Quantities of Military Leadership. Edward Barber. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 48–65. 20 references.

Air-Head Logistics. Jasper N. Bell. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 39–47.

U.S. Economic Prospects. Herman Beukema. *Air University Quarterly Review*, Vol. 2, No. 3, Winter, 1948, pp. 14–27.

Navigation (29)

Navigators Need More Help and Space. *Aviation Week*, Vol. 49, No. 21, November 22, 1948, pp. 25, 28, 29, illus. (Extended summary of a paper.)

An analysis was made during arctic operations of the frequency of operation of equipment, the amount of time required to obtain the desired information, and the sequence in which operations were performed, in order to obtain data on which to base the redesign of navigation instruments and aircraft interiors.

'Picture' Navigation for Personal Planes. *Southern Flight*, Vol. 30, No. 6, December, 1948, pp. 15, 21, illus.

The Lear Omnimatic, a cathode-ray automatic bearing indicator consisting of a V.H.F. receiver, V.H.F. transmitter, Omnipak power supply, Omniscope indicator, and accessories as required, including a V antenna. Drawing about 7 amp. at 14 volts and about 3.5 amp. at 28 volts, the equipment presents a visual bearing indication of the selected omni-range station. All components weigh less than 30 lbs.

The Lear Omnimatic System. Leighton Collins. *Air Facts*, Vol. 11, No. 12, December 1, 1948, pp. 24–33, 36–43, illus.

Letters to the Editor: Homing Pigeon in Electromagnetic Fields. C. L. Clark, R. A. Peck, Jr., and W. F. Hollander. *Journal of Applied Physics*, Vol. 19, No. 12, December, 1948, p. 1183. 1 reference.

During and after subjection to controlled magnetic, electric, and radio-frequency radiation fields of varying intensity, the pigeon did not exhibit any signs that any special sensory apparatus it may have was overstimulated to the point of discomfort.

Photography (26)

Photogrammetric Orientation Data and Determination of Their Accuracy. Percy Tham. (*Kungliga Tekniska Högskola, Handlingar Nr. 14*, 1947.) *Acta Polytechnica* (Stockholm), No. 19 (*Physics and Applied Mathematics Series*, Vol. 1, No. 4), 1948. 38 pp., figs. 4 references. Sw. Kr. 2:50.

The determination of the position of an air photograph with reference to the ground is further facilitated (1) by the addition of the missing relation of tilt to von Gruber's method for the solution of photogrammetric resection, (2) by elucidation of the methods of determining the accuracy in the orientation data in those cases where supernumerary measurements are available, and (3) by the determination of the accuracy in the coefficients of the mathematical perspective, which is made with supernumerary measurements in order to compute the most probable shape of the generating pencil of rays. The method can be used for testing the accuracy of altimeters used in photogrammetry, for accurate comparison of altimeters, for testing instruments that record relative variations in airplane altitude (such as stratoscopes), and for a check on the horizon traces pertaining to the Nononen method.

Continuous Oscillograph Camera for Ionosphere Measurements. James E. Hacke, Jr. *Instruments*, Vol. 21, No. 10, October, 1948, pp. 914, 915, illus.

Power Plants

What's Retarding Engine Control Progress? R. R. Higginbotham. *SAE Journal*, Vol. 56, No. 12, December, 1948, pp. 30–34, illus., cutaway drawing. (Extended summary of a paper: Ancestor Worship in Engine Control Design.)

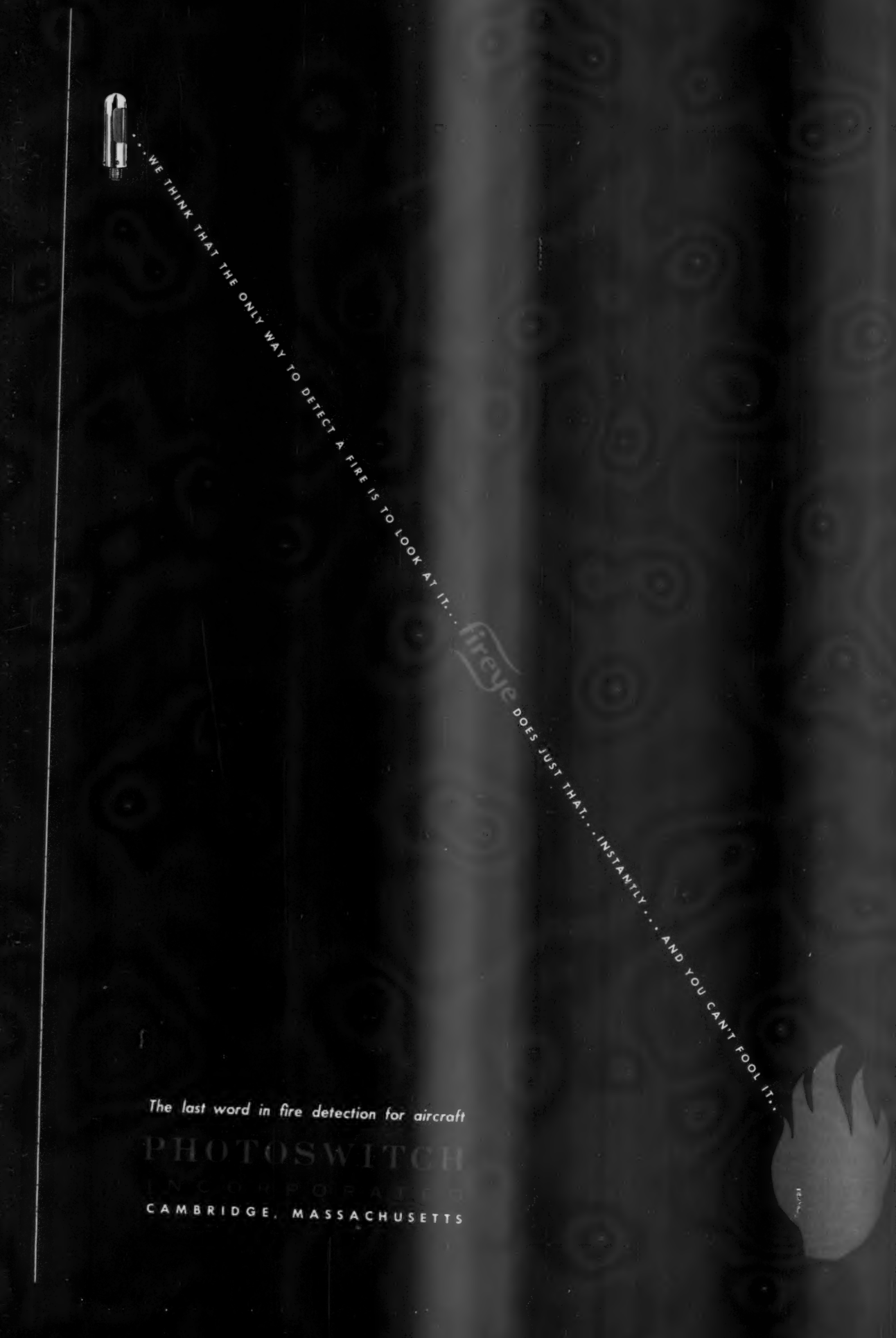
Filtration as Applied to the Aircraft Industry. J. Parkinson. *Aircraft Engineering*, Vol. 20, No. 237, November, 1948, pp. 337–343, illus., figs. 4 references.

The requirements of air, fuel and oil filters, and a survey of the designs currently finding application in the lubricant, fuel, and air-intake systems of reciprocating and gas-turbine aircraft power plants, and in test-bed installations.

JET & TURBINE (5)

Power Boosting of Jet Engines by Reheat. A. D. Baxter and C. Kell. *Aircraft Engineering*, Vol. 20, No. 238, December, 1948, pp. 361–365, figs.

The Rolls-Royce W/2B23 engines of a Meteor jet aircraft were modified by a fuel-injection system and combustion chamber installed between the turbine and the exhaust nozzle. The additional thrust given by this afterburner increased the level flight speed by 45 m.p.h. at altitudes up to 10,000 ft. and improved the estimated rate of climb 40 per cent at ground level. The modified engine was roughly equivalent to a simple jet engine with 20 per cent greater thrust and 30 per cent greater fuel consumption. The original ignition system contained a pilot jet. However, because of its sensitivity to variations in the rate of flow of fuel to the pilot jet and consequent variations in the fuel-air mixture ratio, the system was replaced by a flame tube with a continuous spark to which pilot fuel was blown back from the main fuel-injection orifices. Since a variable-area exhaust nozzle was not used, a


. . . WE THINK THAT THE ONLY WAY TO DETECT A FIRE IS TO LOOK AT IT. . .
fireye
DOES JUST THAT. . . INSTANTLY . . . AND YOU CAN'T FOOL IT. . .
The last word in fire detection for aircraft
PHOTOSWITCH
INCORPORATED
CAMBRIDGE, MASSACHUSETTS

fixed-area nozzle of compromise dimensions was selected which adequately protected the main engine from the increased exhaust back pressure and the consequent increased combustion-chamber temperature.

Testing of Jet Engines Under Simulated Air-Speed and Altitude Conditions. J. F. Manildi. *Aeronautical Engineering Review*, Vol. 8, No. 2, February, 1949, pp. 34–38, diagrs.

The power-requirement and heat-dissipation problems that are encountered when jet engines are tested in open or closed wind tunnels can be avoided by connecting the air intake of the engine directly to a source of compressed air. Such a pressurized tank serves as a means of simulating the ram effect of forward air speed. A similar evacuated chamber, flexibly coupled to the engine exhaust, can be used to simulate high-altitude operating conditions. This pressurized-tank testing technique simplifies the evaluation of the internal performance of the engine because it does not require that the effects of external flow and associated aerodynamic drag be taken into account in interpreting the test data. However, care must be taken with pulsating engines so that the effects of pressure-wave reflections in the tank, which are not characteristic of free-flight operation, are made negligible.

Control Considerations for Optimum Power Proportionment in Turbine-Propeller Engines. Marcus F. Heidmann and David Novik. *U.S., N.A.C.A., Technical Note No. 1762*, December, 1948. 34 pp., diagr., figs. 2 references.

An analysis of a turbine-propeller engine operating at constant speed with critical flow existing at the turbine nozzles showed that the gains to be derived from the optimum proportionment of power between propeller and thrust nozzle vary with propeller characteristics. The selection of a propeller with the proper characteristics can minimize the need of controlled power proportionment. If the specifications require a propeller that cannot efficiently absorb the engine power under all flight conditions, the utilization of the available energy can be improved by controlling the proportionment of power. Although the theoretical expression for variation of a completely variable nozzle area with optimum power proportionment is too complex to be used in the design of a practical control system, adequate proportionment can be obtained, for an engine with varying propeller and turbine efficiencies, by the use of a two- or three-position nozzle-area control.

Centrifugal and Thermal Stresses in Rotating Disks. W. R. Leopold. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 322–326, figs. 5 references.

A method of calculating the stresses in rotating discs which is quicker than tabular methods in common use and more complete than sum-and-difference systems. The actual disc profile is replaced by a series of constant-thickness cylinders, the approximate radial temperature gradient of which is approximated by an exponential function of the radius. A tabular form sheet is made by using the physical properties of the disc. These values are integrated graphically and the results corrected to obtain the stresses throughout the disc. This type of analysis is accurate only up to the yield point of the material.

Rotating Disks at High Temperature. W. Leopold. *Machine Design*, Vol. 20, No. 12, December, 1948, pp. 141–145, figs. 4 references.

Tabular method for the calculation of centrifugal and thermal stresses. Presently used solutions neglect radial temperature gradients and the resulting thermal stress that occurs in modern, high-temperature design. When a temperature gradient exists, compressive circumferential stresses are superposed upon tensile centrifugal stresses caused by rotation, a factor that determines the value of stress existing under the combination of the temperature gradient and rotation. The most favorable condition exists when the thermal compressive stress and centrifugal tensile stress combine to give a small positive tensile value. A compromise must be made between the cold condition and that existing with a temperature gradient, since, in order to allow the disc to expand radially and to permit an increase in centrifugal tensile stress, the hub would have to be weakened. The solutions satisfying the actual radial conditions are obtained from combining the two stress distributions. By this method, a rapid and accurate analysis of any rotating disc is possible.

Readers' Forum: Rotary Compressors. Hunt Davis, D. G. Traver, and A. M. G. Moody. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, pp. 124, 125. 3 references.

Temperature Measurements in High-Velocity Gas Streams. Lars Malmquist. (*Kungliga Tekniska Högskola, Handlingar Nr. 15*, 1948.) *Acta Polytechnica* (Stockholm), No. 24 (*Mechanical Engineering Series*, Vol. 1, No. 4), 1948. 54 pp., diagrs., figs. 10 references. Sw. Kr. 3.

An investigation concerning stagnation-temperature probes in cold and hot high-velocity air streams which began with tests on probes similar to that developed by Pratt & Whitney in 1945. Tests were carried out on an improved type equipped with a double tube to provide an insulating layer of air in the gap between the tubes and with vent holes placed downstream of the thermocouple junctions so as to bring about a more uniform and effective heat transfer to the junction. The recovery factor was found to be 99.8 or even more in cold air. In a stream of hot air at a temperature of about 250°C. discharged into free air, the recovery factor did not deviate from 100 per cent to any notable extent. It was found that the error in the improved stagnant-temperature probe does not exceed 0.3°C. at subsonic velocities of flow, even if the difference between the stagnation temperature of the gas and the temperature of the radiant surfaces in the surroundings is as high as 300°C. This temperature probe can be used for accurate temperature measurements in free gas streams at relatively high temperatures.

Multijet Airplane Starter-Generator Controls. V. B. Hart. *Electrical Engineering*, Vol. 67, No. 12, December, 1948, p. 1166. (Summary of a paper: Starter-Generator Control System for a Multijet Airplane.)

An automatic starter-generator control system has reduced the total engine starting time of a six-engined jet aircraft from 15 to 5 min. A saving of 215 lbs. in the weight of the airplane was obtained by using common power leads for both starting and generating. The provision of an automatic disconnect of the generator's equalizer circuit permitted maximum system stability to be maintained with one or more generators inoperative.

Investigation of Gas Turbine and Jet Propulsion Work in Paris. R. S. Sproule, V. W. Peterson, and R. R. Pattison. *Combined Intelligence Objectives Sub-Committee, Item Nos. 25, 26, File Nos. 4-1*, 8. 30 pp. British Information Services, New York, $0.90.

Investigation of 23 targets in the Paris area. Information was obtained on a duplex fuel system for the BMW 801, a method of finning the cylinders, and a technique for chrome-plating the bores of the 801 cylinders; and also on a double-motor, electric pitch-change mechanism for the Me P.8 propeller, which employs a traversing ring behind the propeller shaft. The ring is trunnion-fixed to the outer race of a ball bearing; the inner race can slide along the propeller shaft. The blades are turned by the movement of the inner race, which is transmitted to offset pins on the bases of the blade hubs.

Gas Turbine Development B.M.W., Junkers, Daimler Benz. P. Lloyd. *Combined Intelligence Objectives Sub-Committee, Item Nos. 5, 26, File No. 24-6*. 29 pp., figs. British Information Services, New York. $1.00.

Résumé of the development and descriptions of the BMW 003 and 018 turbojet, the BMW 028 turboprop, and the BMW 003R, a turbojet engine with a bifuel rocket augmentor. In the Daimler-Benz double-circuit turbojet engine, the airflow through the main compressor, combustion system, and turbine was augmented by a secondary airflow that was supplied by a rotating drum containing three stages of fan blading on its outer surface; this drum was concentric to, and rotated outside, a smaller drum that comprised the compressor. Junkers developments were the 004A, 004B, 0012, 033, and the 004 turbojet engines.

Armstrong Siddeley 'Mamba 1' Engine. *Hawker Siddeley Review*, Vol. 1, No. 4, November, 1948, pp. 25, 26, illus. Specifications of the engine and accessories, and performance tables.

Fir-Tree Broaching; Weatherley Oilgear (Ltd.) Tooling for Simultaneous Machining of Blade-Roots and Rotor Discs. *Aircraft Production*, Vol. 10, No. 122, December, 1948, pp. 423–427, illus., diagrs.

The tooling of XD 20 by 54 machines produces externally and internally mating versions of the same profile for compressor and turbine rotors. With double-slide vertical surfaces of variable-speed pull-down type with alternating tool slides and interlocked automatic shuttle tables, they can be set at manual, semiautomatic or fully automatic. The tooling is notable in that the fixtures can be adapted to a considerable range of sizes with a high rate of production.

The Servicing of Gas Turbines. R. A. Fry. *The Technical Instructor*, Vol. 3, No. 11, November, 1948, pp. 3–8, diagr. Detailed procedures for trouble-shooting, and daily major and minor inspections.

RECIPROCATING (6)

Engine Conditioning. II—Basic Engine Operation. *Aviation Maintenance & Operations*, Vol. 2, No. 1, December, 1948, pp. 24–27, 56, 58, 60, 62, 64–67, figs.

Basic operating principles of the 4-cycle internal combustion engine and their relation to performance characteristics and maintainence procedures. It includes: cylinder compression, fuel-air mixture, cylinder temperature and injection cooling, carburation valve adjustment and cam-bearing clearance, the ignition system and its components, and the propeller-governor control.

Latest Piston Powerplant: R-2180; P & W's New Engine, Intended for DC-54 Conversion. Irving Stone. *Aviation Week*, Vol. 49, No. 21, November 22, 1948, pp. 20–22, illus., fig.

How to Service Spark Plugs and Ignition Wiring. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, pp. 30–32, 37, illus.

How to Boost Engine Output. R. J. S. Pigott. *SAE Journal*, Vol. 56, No. 12, December, 1948, pp. 35–38, diagrs., figs. (Extended summary of a paper: High Output Engines.)

Lubrication Between the Piston Rings and Cylinder Wall of a Running Engine. J. S. Courtney-Pratt and G. K. Tudor. *Australia, Council for Scientific and Industrial Research, Bulletin No. 179*, 1944. 51 pp., illus., figs. 8 references.

ROCKET (4)

Rocket Motors. George P. Sutton. *Machine Design*, Vol. 20, No. 12, December, 1948, pp. 101–105, illus., diagrs., figs. 2 references.

Design problems of liquid-propellant rocket power plants. Operating conditions with flame temperatures in the vicinity of 5,000°F. and gas velocities usually in excess of 1 mile per sec. require high heat transfer, a level of precision for fabrication tolerances, and provision for high varying pressures. Heat transfer, most intense in the nozzle throat, causes effects on the rocket wall which include the expansion of all components, the weakening of wall material, and stresses that are additional to those imposed by chamber and cooling jacket pressures. Thermal stresses will be proportional to the temperature differential across the wall and will depend on the properties of the wall material. Research on the application of ceramic coatings or on sandwich construction might result in a favorable combination. Expansion joints and controlled coolant pressures are partial solutions. Fabrication tolerances of the order of 0.0005-in. for the diameter of the injection orifices that control the fuel ratio and severe welding requirements using pressure and X-ray tests are others.

The Design of Tanks for Liquid-Propellant Rocket Power Plants. C. C. Ross and R. B. Young. *American Rocket Society, Journal*, No. 75, September-December, 1948, pp. 107–118, diagrs. 2 references.

Résumé of current tank and gas-flask design practice for bifuel rocket power plants and typical configurations of the oxidizer-, fuel-, gas-tank assembly of pump-fed fuel systems. The physical properties are given for aluminum and steel alloys which meet the strength, weight, corrosion resistance, and cost requirements imposed on fuel and oxidizer tanks by manufacturing and operating conditions. The design details of tanks for high-pressure systems are dictated by filling, cleaning, and refilling requirements; storage and handling conditions; flight and thrust loads; and the uninterrupted character of the flow from the propellant tanks which must be maintained under accelerations of varying magnitudes in six directions.

Design and Fabrication of Welded Lightweight Pressure Vessels. J. J. Chyle. *American Rocket Society, Journal*, No. 75, September-December, 1948, pp. 90–106, illus., figs.

Design and fabrication of lightweight vessels for rocket-engine fuel and compressed-gas containers, which operate at high pressures under high, low, and normal temperatures. Includes the effect of operating stresses and safety factors on the selection of materials and the welding process, inspection methods, heat-treatment, proof testing, and final qualification of the products, and illustrative numerical data.

Tank Pressure from Combustion Chamber. Edward F. Chandler. *American Rocket Society, Journal*, No. 75, September-December, 1948, pp. 119–121, diagr.

A development of the one-shot system liquid-fuel jet power plant. A powder charge is set off in the combustion chamber, supplies initial thrust, and reduces to a minimum the time required for maximum thrust to be built up. The full working pressure, when attained, initiates the injection of the liquid propellants, and the heat generated by the starting charge provides ignition. Gases bled from the combustion chamber at combustion-chamber pressure pressurize the propellant tanks and effect the fuel injection. This pressure-bleed eliminates the need for a storage container of gas under high pressure.

Five-Pound Thrust Liquid Monopropellant Rocket. Manuel C. Sanz. *American Rocket Society, Journal*, No. 75, September-December, 1948, pp. 122–125, illus., diagr.

Design, construction, method of launching and firing, and the results of static tests of an experimental rocket 16 in. in length and $1^1/_4$ in. in diameter. The concentrated hydrogen-peroxide fuel tank is pressurized with carbon dioxide obtained from a small commercial bulb. A solid catalyst, held in discs of wire-mesh window screening, decomposed the propellant. In a powered flight of about $8^1/_2$ sec. duration an altitude of approximately 6,000 ft. was attained.

The Synergy Curve. II. Hermann Oberth. Translated by Alfred J. Zaehringer. (*Wege zum Raumschiffahrt*, Munich, 1929, pp. 177–185.) *Rocketscience*, Vol. 2, No. 4, December, 1948, pp. 60–63, fig.

Production (36)

Production Developments. D. C. Robinson. *Aircraft Production*, Vol. 10, No. 122, December, 1948, pp. 408–412, diagrs. (Abridged.)

In aircraft assembly, maintaining large and efficient production and flexibility for rapidly introduced changes in design is desired. Requirements from personnel are great. Practical-minded designers and technical-minded production engineers and the degree of cooperation between them will determine flexibility and the period of time between design and flight. Designers should have consideration for reasonable methods of production, and production engineers should employ the maximum use of mechanical processes to minimize the need for the transfer of technical data in detail drawings for marking off and setting up. Decision on the aircraft's major components is the first stage of agreement. The second occurs when jig-and-tool and production departments break these units still further into assemblies and subassemblies. In the making of the assembly erection jigs, complete out-of-jig drilling and fabrication and assemblage of detail parts eliminates the need for drawings other than manufacturing drawings of the components or assemblies. The number of drawings required and the time in the jig are reduced, and the capacity of the tool is increased. Forming and stretching of metal will be augmented by forming of sandwiched plastics, which will further reduce the need for drawings and setting up. Yet it is cooperation in understanding the human characteristic of slow adaptation to change which will determine the achievement of the real progress desired.

Hawker Sea Fury. III—Mainplane Construction: Building the Main Spars: Leading- and Trailing-Edge Sub-Assemblies: Final Assembly. S. C. Poulsen. *Aircraft Production*, Vol. 10, No. 122, December, 1948, pp. 413–422, illus., cutaway drawings. Exacting design requirements are reduced through extensive use of rubber-die-pressed details.

'Produceability.' *Aviation Week*, Vol. 49, No. 22, November 29, 1948, p. 17.

Basic criteria used by Industrial Planning Division of the Air Materiel Command to rate the producibility of an aircraft design are: simplicity of configuration; number and diversity of parts; breakdown into assemblies and subassemblies; ease of equipment installation, inspection, and replacement; availability of materials; availability of machine tooling for processes to be used; and standardization. The redesign of aircraft according to these standards has resulted in substantial savings in production costs. Production studies sponsored by the division are directed toward increasing manufacturing efficiency and capacity.

Engineering Scheduling and Control. Grayson D. Kirtland. *Product Engineering*, Vol. 19, No. 12, December, 1948, pp. 102–105, illus., figs.

Visual production control board with horizontal and vertical tape pegs manufactured by the Wassell Organization, Inc. A Cardex file identifies a job card with each horizontal line of the board. Overall and current operation schedules are posted. A rectangular peg shows the operation involved; two round pegs show the starting and finishing dates. A vertical "today's date" tape is moved each day, and, as it passes a finish date, colored

S-700
S-200
S-100
S-50
S-25
V-15

S-700

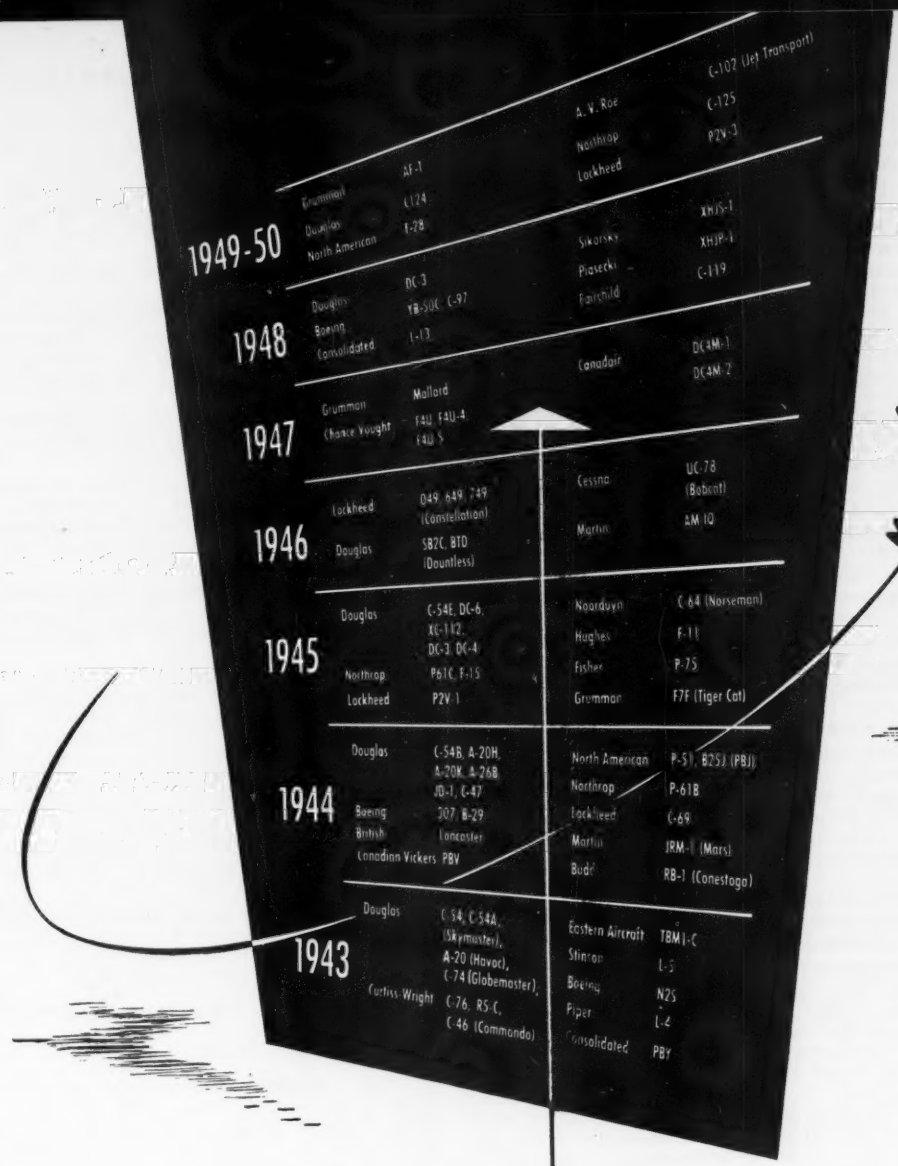
S-200

S-100

S-50

S-25

V-15



just plane addition . . .

. . . points to unquestioned leadership of Janitrol heaters. There's no better proof of performance than the long list of fine aircraft which are Janitrol-equipped . . . For the smallest or the largest airplane—for all heating requirements—in flight, or on the ground—Janitrol heaters will live up to the severest specs. They're as compact, as lightweight, as sturdy, and as dependable as modern engineering can make them. You'll be well advised, whatever your heating problem, to call in your nearest Janitrol representative early in the design stage. A phone call will put him at your service.

Janitrol

AIRCRAFT AND AUTOMOTIVE HEATERS *with the whirling flame*

AIRCRAFT-AUTOMOTIVE DIVISION • SURFACE COMBUSTION CORP., TOLEDO 1, OHIO

New York, N. Y., 225 Broadway • Kansas City, Mo., 950 Dierks Building • Los Angeles, Calif., 536 Petroleum Building • San Francisco, Calif., 1150 Folsom Street
Central District Office, Engineering Development and Production, Columbus, Ohio • Headquarters, Toledo, Ohio

pegs are used for follow-ups and degrees of action taken. The board shows numerous details of control, the status of each job by visual indication, lagging operations, whether follow-up is scheduled, and whether such action actually has been undertaken.

Quality Control; An Ultra-Simplified Method of Chart-Construction and Use. H. Howell. *Aircraft Production*, Vol. 10, No. 122, December, 1948, pp. 404, 405, tables.

A set of tables and charts that eliminate the arithmetical work ordinarily required to determine the quality of a product by the application of statistical theory to inspection data obtained by sampling. None of the precision of the statistical device is lost. The method not only simplifies the control of the quality of the product but also provides a means of evaluating the precision of the manufacturing process and of predicting the quality of the bulk product.

The Foreman's View of Quality Control. Wade R. Weaver. *Industrial Quality Control*, Vol. 5, No. 3, November, 1948, pp. 19–22, figs.

Administration of a Sampling Inspection Plan. Harold F. Dodge. *Industrial Quality Control*, Vol. 5, No. 3, November, 1948, pp. 12–19, figs. 2 references.

Tolerances—Additive or Pythagorean? F. S. Action and E. G. Olds. *Industrial Quality Control*, Vol. 5, No. 3, November, 1948, pp. 6–12, figs.

Production Processes; Their Influence on Design. XXXIX—Seam Welding. Roger W. Bolz. *Machine Design*, Vol. 20, No. 12, December, 1948, pp. 115–121, illus., figs. Illustrated classification of seam welds and standard or special seam-welding machines.

Improved Forming Technique at Northrop. T. E. Piper and Al Schoellerman. *Automotive Industries*, Vol. 99, No. 11, December 1, 1948, pp. 40–43, 78, diagrs., figs.

Although 75S alloy has desirable higher physical properties, it requires a large radius when formed at room temperatures with conventional punches. Northrop Aircraft successfully reduced its minimum radii bend at room temperatures to the same as that used for 24 STAL by milling a flat with rounded corners on the nose of the punch. A conversion formula for the punch is worked out for gages between 0.032 and 0.125.

Greater Capacity Presses Increase Possibilities for Stretch Forming. J. J. Sloan. *Automotive Industries*, Vol. 99, No. 12, December 15, 1948, pp. 36–40, 58, illus., diagrs.

The versatility and limitations of the Hufford Model 50 stretch press. Soft aluminum alloys, corrosion-resistant steel, and 75S-T in the "as quench" state can be shaped by being stretched over contoured dies. The method reduces spring-back, permits the number of separate pieces in a section to be reduced, gives parts of greater uniformity, and allows the angles between legs of a section to be varied on the die instead of by hand. Its chief disadvantage is that curvature is, in most cases, limited to a single plane.

Elimination of Standing Waves on Electrodes for High-Frequency Dielectric Heating. E. R. Bell and M. E. Dunlap. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 24, December 15, 1948, pp. 13–21, illus., diagrs., figs. 2 references.

Tests conducted at the Forest Products Laboratory on the dielectric heating of 25-ft. laminar aircraft spars showed that variations in temperature along the spar which are caused by standing waves on the electrodes can be eliminated by using relatively high frequencies and multiple-tuned electrodes or, if low frequencies are used, by connecting the generator to two or more points on the electrodes. Both techniques appear to be equally satisfactory. The low-frequency method can be used with members of any length by heating short sections successively. The temperatures and voltages that were measured confirmed the equality that exists between the ratio of minimum to maximum dielectric temperature and the squared ratio of minimum to maximum peak voltage measured across the electrodes.

Propellers (11)

The Vibration of Propeller Blades. G. A. Dirac. *Aircraft Engineering*, Vol. 20, No. 237, November, 1948, pp. 322–329, 343, figs.

An analysis of the torsional and lateral vibration of a propeller blade developed from the simple case of a bar clamped at one end. The density and elastic properties of the bar are assumed to be uniform. The characteristics of a blade cross section are assumed to be regular functions of its distance from the blade root along its axis and thus susceptible of expansion in Fourier or power series in terms of this distance. The equations determining characteristic frequencies in torsion and lateral vibration are obtained in the form of determinants with the conditions for their convergence expressed in terms of the coefficients of the power-series expansion. The rapidity of convergence in practical cases can be estimated. The formulas can be used to find the response to a propeller to periodic forces and couples in bending and in torsion and the maximum displacement at any input frequency. The errors inherent in the assumptions and in the mathematical solution are estimated. The procedure for solving a problem is explained.

Reversing Propellers for Airline Use. Jerry Leichter. *Airports and Air Carriers*, Vol. 14, No. 6, December, 1948, pp. 10, 11, diagrs.

The disadvantages of the use of reverse thrust as an aircraft brake during landing and the advantages that could be afforded in accident prevention and airport-runway economy by the installation of this system in commercial transport aircraft are given in this article.

The NACA Hydraulic Torque System for Indicating Propeller Torque. Richard J. Moberg and Edward B. Palazzo. *Instruments*, Vol. 21, No. 12, December, 1948, pp. 1100–1102, illus., diagrs.

Hydraulic transmission of propeller torque for readings on a standard Toledo "Printweight" compensating scale. Readings are recorded automatically with other force data, thereby eliminating the extra personnel required with other systems. The system shows $2^1/_2$ months of operation with no maintenance. Movement of parts is practically nonexistent, and changes and differentials of temperature, humidity, and pressure have no appreciable effect on readings.

Extruded Aluminum Propeller Blades and Hub. Walter H. Korff. *Product Engineering*, Vol. 19, No. 12, December, 1948, p. 127, illus. (Cf. AER 1/49:65.)

Canadian Propeller Maker (S & S Products Company). *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, pp. 26, 27, illus.

Reference Literature (47)

BIBLIOGRAPHIES

Reports and Memoranda Published Between 1st January, 1947, and 30th June, 1947. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2250*, June, 1947. 5 pp. British Information Services, New York. $0.45.

A numerical list of 99 *R. & M.'s*, Nos. 2151 to 2250, excluding No. 2232, which is not yet available. The Aeronautical Research Council reference number, title, author, and date of the annual technical volume in which each *R. & M.* will be re-published are given for each entry. Prices are not listed.

Abstracts of Papers Published Externally. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2380*, August, 1948. 15 pp. British Information Services, New York. $1.00.

Abstracts of 14 papers discussed by the Aeronautical Research Council and recommended for external publication. The papers were published between June, 1941, and February, 1948, in, with one exception, English scientific journals and trade periodicals. The reference to the periodical of publication and the Aeronautical Research Council reference number are given in each case. Some of the bibliographic references from the original papers are reproduced. Contents: A Contribution to the Theory of Axial Blade Grids, R. E. Meyer. Note on Biot's Dynamic Modulus, W. J. Duncan. The Admittance Method for Obtaining the Natural Frequencies of Systems, W. J. Duncan. The Turbulent Spreading of a Water Jet, A. M. Binnie. The Design of Trusses and its Influence on Weight and Stiffness, Jean Drymael. Free and Forced Oscillations of Continuous Beams: Treatment by the Admittance Method, W. J. Duncan. Wood Smoke as a Means of Visualizing Boundary Layer Flow at High Reynolds Numbers, J. H. Preston and N. E. Sweeting. A Method for the Solution of Biquadratic Equations, W. S. Brown. Some Devices for the Solution of Large Sets of Simultaneous Linear Equations, W. J. Duncan. Fractorisation of a Class of Determinants and Applications to Dynamical Chains, W. J. Duncan. The Principal Directions of Loading and the Principal Directions of Forced Oscilla-

HAGAN'S *New* INTEGRAL BEAM

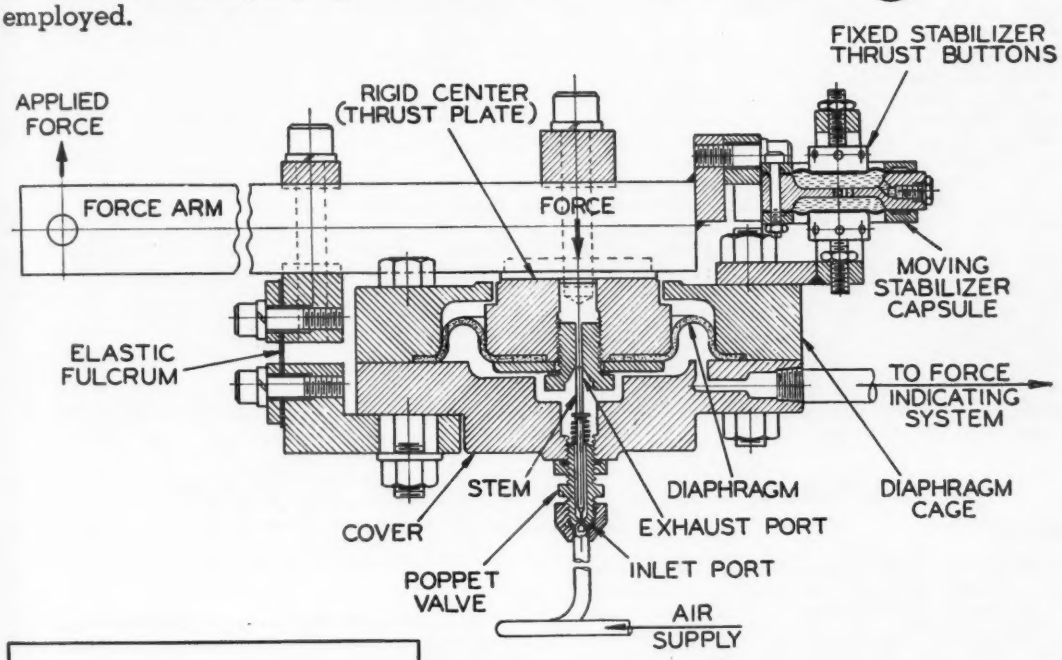
THRUSTORQ FOR LOW LOADS

offers these advantages

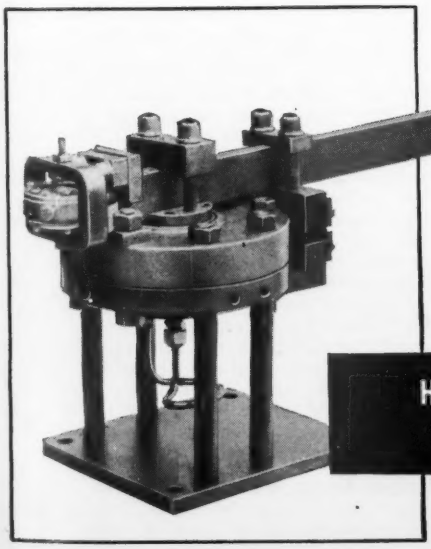
1. **Greater convenience,** because the beam is easily linked to the device with which it is to be used.

2. **Greater sensitivity,** because the beam mechanically multiplies the force to be measured.

3. **Greater accuracy** at low loads, partly because of the force-multiplying effect of the beam and partly because of the unusual damping system which is employed.



As the diagram shows, this model employs the same basic principle as other THRUSTORQS, but incorporates a force arm and stabilizing capsule as integral parts of the unit.



For full information on this and other Hagan THRUSTORQS, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN THRUSTORQ measuring thrust and torque *with air!*

HAGAN HALL BUROMIN CALGON

tion at a Point of an Elastic Body or System, W. J. Duncan. BiVariate Partial Fractions and Their Applications to Flutter and Stability Problems, R. A. Frazer. Decay of Vorticity in Isotropic Turbulence, G. K. Batchelor and A. A. Townsend. Semi-Rigid Representation of Elastic Cantilevers for Torsion Problems in Aerodynamics. A. R. Collar.

Use of a Technical Library. R. H. Whitford and J. B. O'Farrell. *Mechanical Engineering*, Vol. 70, No. 12, December, 1948, pp. 987–993. 19 references.

Rotating Wing Aircraft (34)

A Theoretical Study of the Dynamic Properties of Helicopter-Blade Systems. H. Reissner and M. Morduchow. *U.S., N.A.C.A., Technical Note No. 1430*, November, 1948. 114 pp., figs.

A study of the free oscillation of the blade system of a helicopter about the different steady states of flight in which are derived the angles of attack of the inflow; the blade-position variables, pitch, flapping angle, and lag; and the aerodynamic and inertia forces acting on hinged helicopter blades during hovering and during travel. The equilibrium conditions are developed and solved for the blade system when hovering and when traveling, and, under the same conditions, the frequency, stability, and damping properties are developed for hinged, sufficiently rigid, rotor blades. A method of solution of small oscillations about a state of simultaneous rotation and travel has only been solved for small ratios of blade-tip speed to travel velocity in four cases illustrating diverse constraint conditions between three angles of pitch, flapping, and lagging. The number of modes and of independent amplitudes is equal to the degree of freedom. Each mode in hovering corresponds to one frequency, but during travel, each mode consists of three frequencies of fixed amplitude ratios and phase differences each with only one free amplitude. The amplitude ratios of the two additional frequencies to the original amplitude are, in all cases that have been computed numerically, smaller than the speed ratio. The results show advantages of appropriate kinematic constraints between the three angles in preventing resonance, in damping, and in automatic adjustment.

1948 Rotary Wing Pictorial Review. *American Helicopter*, Vol. 13, No. 1, December, 1948, pp. 10–18, illus. Descriptions and illustrations of 34 U.S. and foreign models.

The Bell (47D) Helicopter. *Aircraft and Airport*, Vol. 10, No. 11, November, 1948, pp. 24, 25, illus.

Sciences, General (33)

MATHEMATICS

On the Harmonic and Bi-Harmonic Problems of a Region Bounded by a Circle and Two Parallel Lines. R. Westberg. (Rec'd. May, 1945.) (*Ingeniörsvetenskapsakademi, Handlingar Nr. 197*, 1948.) *Acta Polytechnica* (Stockholm), No. 18 (*Physics and Applied Mathematics Series*, Vol. 1, No. 3), 1948. 66 pp., figs. 41 references. Sw. Kr. 10.

Determination of the potential function in the region between an infinitely long circular cylinder and two planes parallel to each other and to the axis of the cylinder when the potentials on the surface of the cylinder and on each plane assume known constant values. The relatively complete treatment affords good guidance for the treatment of certain problems within the theory of elasticity and hydrodynamics. In these, the boundaries have the same form as in the potential problem under consideration, but the function required must satisfy the biharmonic differential equation instead of the harmonic, and the boundary conditions are naturally different. The problems can be treated analogously to the simpler potential problem. In a plane section perpendicular to the axis of the cylinder, where the cylinder is represented by a circle and the two planes by two lines, the potential problem can be reduced to two simpler ones: viz., where the potential is constant on the circle and zero on both the lines and where the potential varies as a certain cosine function on the circle and is zero on the lines. The potential functions are written in the form of infinite sums of harmonic functions, each of which is zero on the lines and contains an arbitrary coefficient as a factor. After expanding the potential functions in Fourier series, the boundary conditions on the circle give infinite sets of linear equations for the determination of the coefficients. The solutions of the sets of equations are obtained in the form of recurrence formulas, and the necessary demonstrations of convergence are carried out. The desired potential functions are closely analyzed with regard to the position of their singularities, and certain regions are determined within which the singular points are located. Using these results, the regions of convergence for various expansions in series of the potential functions can be determined. A large number of coefficients in some of the expansions are computed numerically, so that the potential can be calculated simply in the entire region between the circle and the lines if the ratio between the diameter of the circle and the distance between the lines is not too large (about 0. 9).

Mathematics for Engineers. III—Dimensional Analysis of Partial Differential Equations. Garrett Birkhoff. *Electrical Engineering*, Vol. 67, No. 12, December, 1948, pp. 1185–1188. 4 references.

MECHANICS

Gyroscopic Effects on the Critical Speeds of Flexible Rotors. R. B. Green. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 369–376, figs. 3 references.

The method of Den Hertog is used to find the forces and moments on rotating discs for the general case. The various possible criticals of common rotor systems are determined and plotted for all degrees of gyroscopic effect. Specific examples show a cantilever system, two simply supported single-disc systems, a double-disc system, and an infinite-disc system. The gyroscopic effect is shown for all degrees and for all possible ratios of shaft frequency to whirl or precession frequency.

Structures (7)

Some Aeroelastic Properties of Swept Wings. S. I. Pai and W. R. Sears. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, pp. 105–115, 119, diagrs., figs. 11 references.

The lift distribution of an elastic airfoil with sweep has been calculated by a method that in many practical cases does not require the modes of elastic deflections to be assumed. The only restriction placed on elastic theory and aerodynamic theory is that they be linear and one-dimensional. Sample calculations of lift distribution, torsional divergence, and aileron effectiveness confirm the known behavior of sweptback and sweptforward wings. A dive pull-out at constant speed illustrates a case in which the several variables involved are related by the airplane's dynamic equations. The case shows that the destabilizing effect of elastic deflection under air load is partially counteracted by the effects of deflection under inertia load. A simplified dynamic case involving wing bending and airplane longitudinal motion with sweepback shows the possibilities not only of divergence but also of unstable oscillations when the natural frequencies in bending are low.

Principles of Structural Design for Minimum Weight. F. R. Shanley. *Journal of the Aeronautical Sciences*, Vol. 16, No. 3 March, 1949, pp. 133–149, 188, figs. 11 references.

For a given material and type of structure a structural index can be established. This measure of loading intensity can be used to determine the lightest practical arrangement of material which will transmit the required loads through specified distances. Test data for various types of construction and different materials can be compared by the index in order to determine, for a given material, the optimum proportions for minimum weight and, for various design and loading conditions, the optimum materials. The allowable stress for structures subject to buckling can be determined from straight-line approximations of area curves which provide a convenient basis for weight estimation, since they divide the required cross-sectional area into two imaginary parts, one of which depends only on the loading and the material properties and the other of which depends on the dimensions of the structure. The application of the structural index to design problems is illustrated for the tubular column, the stiffened flat plate under axial load, the unstiffened plate with edge support, shear-carrying members, and cylindrical shells in bending. A comparison of materials on a weight basis is made for several aluminum alloys, magnesium alloy, and stainless steel.

Large Cylindrical Bending of Rectangular Plates. H. A. Lang. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 335–343, figs. 4 references.

"She's all warmed up—set her on fire!"

Those are familiar words at the Kidde proving grounds, where we *deliberately* start engine fires by the hundred. What's more, we start them in a roaring wind that doubles for a high-speed slipstream.

How do we do it?

With a pair of B-26 power plants set up in tandem. The propeller of the front engine sends the "slipstream" back through the rear nacelle, where we start the fires.

Why do we do it?

Because only by simulating, as closely as possible, the actual conditions of high-speed flight can we determine the true efficiency of all the many fire-extinguishing agents. It's under conditions like these that we've blasted out engine fires with CO_2, CB, MB, DL, the Freons.

These "in-the-air" studies have provided us with a wealth of data on aviation-fire-fighting—data which we are ready to pass on, at any time, to government agencies, aircraft manufacturers and airline operators.

The word "Kidde" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc.

Kidde

Walter Kidde & Company, Inc. • 411 Main Street, Belleville 9, N. J.

A "power-series" method that may be applied to the bending and buckling of long, thin, rectangular plates when the deflection and curvature are large and the loading is a function of the transverse coordinate only. By removing the condition of continuity, the results may be applied to any general loading. Explicit expressions, to any degree of accuracy, are obtainable for the bending moment, the transverse force, and the deflection. The method is used to verify the theory of bending of a plate under uniform load with edges clamped or pinned. Includes treatment of the problem of the elastica and the effect of discontinuous loads.

The Partitioning of Matrices in Structural Analysis. S. U. Benscoter. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 303–307, figs. 4 references.

A study of typical matrix patterns. Two problems in the torsion of multiple-cell beams illustrate the technique of partitioning complex matrices to obtain submatrices that can be solved readily by explicit formulas.

Bending and Shear Stresses Developed by the Instantaneous Arrest of the Root of a Moving Cantiliver Beam. Elbridge Z. Stowell, Edward B. Schwartz, and John C. Houbolt. *U.S., N.A.C.A., Report No. 828*, 1945. 9 pp., illus., diagrs., figs. 3 references. U.S. Govt. Printing Office, Washington. $0.15.

Theoretical equations for the stresses, deflections, and accelerations that arise in a cantilever beam in transverse motion when its root is brought to rest are verified experimentally. At a given percentage of the distance from root to tip, the bending stresses for a particular mode are independent of the length of the beam, whereas the shear stresses vary inversely with the length.

Notes on Column End-Fixity Coefficients. G. C. Best. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, pp. 117–119, figs. 11 references.

The slope deflection method gives rise to an approximative formula relating column end-fixity coefficients (for beams of constant cross section) to the degree of elastic end restraint. It is assumed that the Euler bending equation applies, that deflections are sufficiently small to permit the substitution of dy^2/dx^2 for M/EI, and that all strains are within the proportional limit. Accuracy is adequate for engineering purposes. N. M. Newmarks approximate formula is shown.

A Simple Approximate Formula for Effective End-Fixity of Columns. N. M. Newmark. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, p. 116.

Simple approximate formulas for numerical values of the end-fixity of a uniform bar, subject to compressive forces with elastic restraints at the ends, were developed at the University of Illinois as part of a project sponsored by the Consolidated Vultee Aircraft Corporation. Critical end load can be stated as a coefficient of end fixity multiplied by the ordinary Euler load for pinned ends.

Recommendations for Numerical Solution of Reinforced-Panel and Fuselage-Ring Problems. N. J. Hoff and Paul A. Libby. *U.S., N.A.C.A., Technical Note No. 1786*, December, 1948. 79 pp., figs., tables. 12 references.

Recommendations for the choice of the most expeditious method of solution of the simultaneous linear equations for the stress distribution in a reinforced panel or the moment distribution in a fuselage ring, when these equations are represented by an operations table established in accordance with Southwell's suggestions, which, together with the external loads, defines the problem completely. Although in most panel problems the relaxation procedure may be used to advantage, the equations defining a reinforced panel problem may better be solved by means of the electric analog if many closely related problems are to be investigated. Matrix methods are the best for the solution of ring problems. When the problems are complicated, it may be advisable to combine the matrix methods with the growing-unit and relaxation methods.

Why Shear Webs? H. L. Cox. *Royal Aeronautical Society, Journal*, Vol. 52, No. 455, November, 1948, pp. 759–761, fig.

A cantilever aircraft wing, if properly shaped, does not require shear webs to bear the stresses caused by the lift. The web at the root, however, carries torsional stresses and throughout the web stabilizes the compression flange buckling. A theoretical survey and experimental investigation indicate that multispar wings with extremely thin webs are practical, provided that the wing axis is curved in the plane of the webs. The total weight of the webs need not exceed one-half of the total weight of the wing cover.

Analysis of Eccentrically Loaded Riveted or Bolted Joints. G. M. Monroe. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, pp. 120–122, figs.

The semigraphical analysis is applicable to all riveted or bolted joints not stressed beyond the elastic limit. The stress on each rivet or bolt is obtained by plotting one point on a scale drawing of the joint and multiplying the distance from this point to each rivet or bolt by a constant factor. The coordinates of the point and the multiplying factor depend only on the loads on the joint, the total rivet area, and the polar moment of inertia of the rivet areas.

Readers' Forum: Stringer Panel and Multicell Wing Construction. Kenneth P. Buchert. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1949, p. 125.

Preliminary Analysis of a Highly Swept Cylindrical Tube Under Torsion and Bending. W. H. Wittrick. *Australia, Council for Aeronautics, Report No. ACA-39*, May, 1948. 23 pp., figs. 3 references.

A theoretical determination of deformation and stresses in a highly swept cylindrical tube of arbitrary section under torsion and bending. Analytical solutions are obtained for the following cases: (a) self-equilibrating stress systems for a tube with the stress bearing area either constant or varying exponentially along the generators, (b) exponential variation of bending moment and torque along the tube defined in (a), and (c) constant bending moments and torque applied to a tube of constant sections. In general, the analysis follows that of Hadji-Argyris and Dunne.

Vibration of a Cantilever Beam with Prescribed End Motion. G. A. Nothmann. *Journal of Applied Mechanics*, Vol. 15, No. 4, December, 1948, pp. 327–334, figs. 2 references.

An analysis of the vibration of a cantilever beam whose moving end is subject to a prescribed displacement law. Laplace operational calculus is used to obtain expressions for the deflection and the shear force at stations along the beam. The shear force at the moving end of the beam, which is equal to the applied end force, may be obtained by superposition of the basic components. The prescribed motion determines the magnitude of the fluctuations and the direction of the corresponding end forces.

Readers' Forum: On Chordwise Divergence. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 16, No. 2, February, 1948, pp. 126, 127, figs. 5 references.

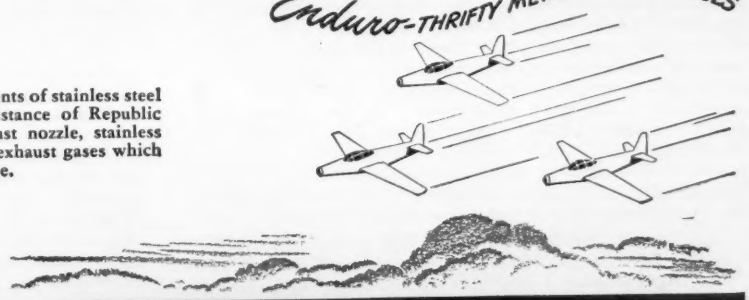
Theory of Wing Flexure-Torsion Flutter. J. Williams. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2274*, July, 1945. 22 pp., figs. 34 references. British Information Services, New York. $1.30.

The theory of wing flutter is analyzed and developed when the wing is encastré at the root, when the control surfaces are locked to the wing and behave as an integral part of the wing structure, and when heavy localized masses such as wing engines are excluded. The wing is treated as a body with two degrees of freedom corresponding to pure flexure and pure torsion. (1) The dynamical equations for small motions of the system are formulated. These equations are briefly discussed to show how flutter can occur and how critical conditions—relating to oscillations of the wing just maintained by energy from the air stream—can be determined theoretically. (2) Expressions for the air loads on the wing, corresponding to small oscillations about small mean incidences, are logically developed by classical derivative theory and by vortex strip theory. The former theory is based on the assumption that the aerodynamic forces may be expressed linearly in terms of the displacement, velocities, and accelerations and employs available experimental measurements of air loads on oscillating wings. The latter theory assumes that the air loads on a local chordwise strip of the wing may be taken as those given by incompressible potential flow theory for oscillations of a two-dimensional flat plate. The critical flutter conditions of the wing follow from the determinantal equation for the compatibility of the dynamical equations relating to simple-harmonic oscillations. Methods of treating this determinantal equation are then fully developed and are compared.

Readers' Forum: Low-Speed Flutter. J. H. Greidanus. *Journal of the Aeronautical Sciences*, Vol. 16 No. 2, February, 1949, pp. 127, 128, fig. 1 reference.

Experimental Verification of Theory of Landing Impact. Walter Ramberg and Albert E. McPherson. *U.S., National Bureau of Standards, Journal of Research*, Vol. 41, No. 5, November, 1948, pp. 509–520, illus., diagrs., figs. 6 references. Available also as *Research Paper No. RP1936*. U.S. Govt. Printing Office, Washington. $0.10.

Enduro-THRIFTY METAL OF 10,000 USES



JET ENGINES—with their various components of stainless steel furnish an outstanding example of the heat-resistance of Republic ENDURO. From combustion chambers to exhaust nozzle, stainless steel holds tight rein on the hurricane of searing exhaust gases which otherwise could easily melt the entire plane structure.

AND SPEAKING OF HEAT-RESISTANCE...

The ability of Republic ENDURO Stainless Steel to maintain its exceptionally high strength in blistering heat and sub-zero cold is but one of the many reasons why this versatile metal is being used for an ever-increasing number of aircraft applications.

High corrosion-resistance, ability to withstand rough usage and abuse, fatigue-resistance . . . all are important ENDURO advantages. Even more important to you is ENDURO's light weight, resulting from an unusually high strength-to-weight ratio. This permits the use of thin, lightweight structural sections.

Whether you are designing the aircraft of tomorrow, or further improving those of today, keep *all* of the advantages of ENDURO Stainless Steel in mind. For additional information or specific technical data, write today to:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Enduro **STAINLESS STEEL**

REG. U. S. PAT. OFF.

REPUBLIC STEEL

✓ **Check ALL 12 advantages:** • RUST AND CORROSION-RESISTANCE • HEAT-RESISTANCE • HIGH MELTING POINT • LOW COEFFICIENT OF EXPANSION • HIGH STRENGTH • GOOD DIMENSIONAL STABILITY • NO METALLIC CONTAMINATION • EASY TO CLEAN • EASY TO FABRICATE • EYE APPEAL • LONG LIFE • LOW END COST

Drop tests of an idealized wing and alighting gear were made to provide an experimental check on methods for computing the transient bending stresses in the wing produced by a symmetrical vertical landing impact. The model was dropped in a nearly strain-free condition to make contact at a point below the center of gravity. The forces in the alighting gear, acceleration at the "fuselage," and bending strains in the wing were recorded as a function of time. According to the statistical theory of Biot and Bisplinghoff, the computed maximum bending stresses, using the first three flexural modes, were found to be 43 to 137 per cent greater than the measured values. Use of the actual forcing function reduced the difference to less than 20 per cent.

The Flexible Rectangular Wing in Roll at Supersonic Flight Speeds. Warren A. Tucker and Robert L. Nelson. *U.S., N.A.C.A., Technical Note No. 1769,* December, 1948. 42 pp., figs. 7 references.

An analysis of the loss in rolling effectiveness of the rectangular wing at supersonic flight speeds. The effects of the loss in lift in the various Mach cones are considered, and equations are obtained from which can be calculated either the loss in the rate of roll due to flexibility or the torsional stiffness required to maintain a given rate of roll for two assumed variations of the spanwise distribution of torsional stiffness. A computation form and figures are provided so that the calculations can be made without reference to the details of the analysis.

Supplement to the Method of Wing Analysis Developed in Reports S.251 and S.279 (Vol. XII). *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport Nr. S.326,* 1947. 3 pp., table. 3 references. (In English.)

When the top and/or bottom skin is absent over part of the span between the spars of a two-spar wing with shear-resistant skin, certain of the functions involved in the calculation of the stress distribution become infinite or indefinite. This difficulty is shown to be only apparent. The Gaussian method of solving a set of simultaneous linear equations is proposed as a revised method of solving the moment equations that arise in wing analysis.

Navy Demonstrates World's Largest Universal Testing Machine. *Instruments,* Vol. 21, No. 10, October, 1948, pp. 876, 878, illus. The Baldwin 5,000,000-lb.-capacity machine.

Mammoth Test Machine. *Naval Aviation News,* No. 20, December, 1948, p. 19, illus. Baldwin 5,000,000-lb.-capacity machine.

Thermodynamics (18)

On the Addition of Heat to a Gas Flowing in a Pipe at Subsonic Speed. Joseph V. Foa and George Rudinger. *Journal of the Aeronautical Sciences,* Vol. 16, No. 2, February, 1949, pp. 84–94, 119, figs. 23 references.

A quantitative treatment of the problem of heat addition to a gas flowing at subsonic speed in a duct of constant cross-sectional area. Previous results have been inadequate. Equations derived in previous publications can only be interpreted as relating the conditions upstream and downstream of the heating region and not before and after the addition of heat. The addition of heat modifies the flow parameters not only downstream but also upstream of the region of heat addition, in a manner that depends on the boundary conditions. The conditions upstream of the region of heat addition should not be taken as the initial conditions. Physical interpretation of results becomes clear when their change is taken into account.

Water-Borne Aircraft (21)

How Flying Boat Scale Models Pre-Prove Design. *Aviation Week,* Vol. 49, No. 22, November 29, 1948, pp. 22, 23, illus.

Radio-controlled, instrumented, flying, replica aircraft models (XP5Y-1, XP4Y-1, and others) used by Consolidated Vultee Aircraft Corporation to determine the c.g. limits of hydrodynamic stability and the landing characteristics with variations of trim and sinking speed. The aerodynamic characteristics of the model are measured while it is mounted on an automobile. These data are obtained from readings of strain gages on the mount and a low-speed air-speed indicator.

Recent N.A.C.A. Research on High Length-Beam Ratio Hulls, Arthur W. Carter. *Journal of the Aeronautical Sciences,* Vol. 16, No. 3, March, 1949, pp. 167–183, 188, illus., figs. 7 references.

An increase in hull length-beam ratio from 6 to 15, when the length-beam product is held constant, reduced the aerodynamic drag without appreciably affecting the hydrodynamic qualities in smooth water, reduced the vertical accelerations and motions during landings in rough water, and reduced the structural weight required for a given load factor. Extreme warping of the forebody planing bottom of length-beam ratio 15 resulted in large reductions in the maximum vertical and angular accelerations during landings in rough water and considerably improved the spray at low speeds. Warping the forebody and extending the afterbody resulted in further reductions in the maximum accelerations in rough-water operation. With hulls of high length-beam ratio, appreciable reductions in aerodynamic drag and hull weight may be obtained. Such high length-beam ratios combined with long afterbodies and warped forebodies are superior to conventional length-beam ratios for rough-water operation.

Hydrodynamic Impact Loads in Rough Water for a Prismatic Float Having an Angle of Dead Rise of 30°. Robert W. Miller. *U.S., N.A.C.A., Technical Note No. 1776,* December, 1948. 27 pp., diagrs., figs. 9 references.

Experimental data for fixed-trim impacts on advancing waves of a prismatic-float forebody 10 ft. in length and having an angle of dead rise of 30°. Theoretical loads calculated on the basis of smooth-water hydrodynamic theory were shown to be in fair agreement with the results of some rough-water impacts for a scalloped-bottom float. Waves used were about 2 ft. in height and 60, 45, or 30 ft. in length. Trims were chosen to compare directly with smooth-water data. Time histories of vertical velocities, horizontal and vertical displacements, and vertical accelerations were recorded for each run, and a force simulating wing lift was applied during impact.

An Empirical Study of Low Aspect Ratio Lifting Surfaces With Particular Regard to Planing Craft. F. W. S. Locke, Jr. *Journal of the Aeronautical Sciences,* Vol. 16, No. 3, March, 1949, pp. 184–188, figs. 11 references.

A brief empirical study shows that the lift coefficient, in incompressible flow of lifting surfaces of aspect ratio less than about 2.0 can be estimated with an accuracy of 10 per cent by an infinite series that is a function of the aspect ratio and the operating conditions: $C_L = \eta K\alpha^n$. When η is assumed to be unity for rectangular plan-form airfoils, it is $^2/_3$ for hulls making leeway and $^1/_2$ for flat-bottom planing surfaces.

An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces. John D. Pierson and Samuel Leshnover. (*Stevens Institute of Technology, Experimental Towing Tank, Report No. 335,* October, 1948.) *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 166,* 1948. 65 pp., figs. 8 references. $1.60.

A detailed study of the planing problem presented by Herbert Wagner. The analysis is based on the Helmholz-Kirchoff method of studying fields of flow that are bounded partly by fixed boundaries and partly by free surfaces. The Schwartz-Christoffel differential equation is used to make conformal transformations of these fields. The properties of the potential flow of an ideal fluid, whose motion over a solid boundary has the form of a sheet of spray as its most important characteristic, are examined in the idealized case of an infinite plane surface planing on the free surface of an ideal fluid at zero angle of trim. In a similar manner, the more realistic case of two-dimensional flow about a planing surface at a positive trim angle, in which the surface has a definite trailing edge, is analyzed. The same method is also used to ascertain the flow around an edge of a solid plane boundary. The load distribution is determined and integrated to obtain the total load sustained by planing bodies and the load variations with each of the several variables. The application of the equations derived is illustrated by discussions of their use in studies of doubly infinite planing surfaces, flat planing surfaces at positive trim, planing surfaces with deadrise, the impact of a body with deadrise, and the flow around an edge of a boundary.

The Discontinuous Fluid Flow Past an Immersed Wedge. B. V. Korvin-Kroukovsky and Faye R. Chabrow. (*Stevens Institute of Technology, Experimental Towing Tank, Report No. 334,* October, 1948.) *Institute of the Aeronautical Sciences, Sherman M. Fairchild Publication Fund, Preprint No. 169,* 1948. 40 pp., figs. 9 references. $1.00.

A contribution to the theoretical study of the potential flow that occurs in the planing of a prismatic body on the surface of water. A mathematical solution for the flow around a submerged wedge is obtained by considering, as a first approximation, that

the water flow under the planing surface takes place in the vertical plane normal to the direction of planing. Velocities and accelerations in the direction of planing are neglected. This approximation reduces the problem of planing to two dimensions and, thereby, the particular case in which the chines are immersed, and the flow that takes place at the aft part of the planing surface becomes identical with the discontinuous fluid flow around the submerged wedge. This is treated by the Helmholz-Kirchoff theory of free jets, and the Schwartz-Christoffel transformation is used to establish the relation between the potential function and the complex coordinate. The solutions yield the equations for the shape of the streamline that breaks away at the chine and for the pressure acting on the planing surface and its distribution and the data that are required for the construction of the flow net of equipotential lines and streamlines.

Economical Aspects of Flying Boats. C. H. Schildhauer. *The Martin Star*, November, 1948, pp. 3, 16, 17 illus. (Extended summary of a paper.)

Wind Tunnels (17)

Vertical Wind Tunnel Added to Air Force Test Facilities. Robert Crawford. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 13, No. 23, December 1, 1948, pp. 8–10, illus.

A closed-circuit atmospheric-pressure tunnel for determining the stability, spin, and recovery characteristics of aircraft models. A velocity of 150 ft. per sec. can be obtained in the 12-ft. diameter test section. The control surfaces of the model are operated by a magnetic mechanism installed within the model. This mechanism is actuated by a magnetic field created by twelve copper bands encircling the test-chamber wall.

Calculation of Tunnel-Induced Upwash Velocities for Swept and Yawed Wings. S. Katzoff and Margery E. Hannah. *U.S., N.A.C.A., Technical Note No. 1748*, November, 1948. 26 pp., figs. 7 references.

The tunnel-induced upwash field for a point element of lift in a rectangular tunnel consists of three superimposed fields. Except for relative position, the fields are independent of the lateral or longitudinal location in the tunnel of the lift element. One field is independent of the type of tunnel and of its width-height ratio. The other two depend on this ratio but are identical except, perhaps, for sign. A contour chart for the first field and for the other field have been prepared for an open tunnel of 2:1 width-height ratio, a closed tunnel of 2:5 width-height ratio, and a closed tunnel of 10:7 width-height ratio. By superposition of results for various locations of the lifting element, the total field can be found for a lifting wing of arbitrary loading and plan form, provided it is situated in the horizontal center plane. The corresponding procedure for nonrectangular tunnels requires the preparation of a chart for each of several spanwise locations of the lifting element.

Captured Wind Tunnel Reaches Mach 5.18. *Aviation Week*, Vol. 49, No. 25, December 20, 1948, p. 30. The "Kochel" wind tunnel at the Naval Ordnance Laboratory, White Oaks, Md.

Note on a Method of Measuring Profile Drag by Means of an Integrating Comb. A. D. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2257*, May, 1938. 8 pp., figs. 5 references. British Information Services, New York. $0.70.

A theoretical investigation and an analysis of test results show that the method for determining the profile drag of a wind by means of an integrating comb, as described by Doetsch, is not accurate enough for ordinary purposes. An improved method was developed which, although more accurate, is too complicated and too sensitive to clogging of its pitot tubes by dust to be used in flight tests, but it is suitable for use in wind tunnels.

The Aerodynamics of Guided Missiles. H. J. Stewart. *Anti-aircraft Journal*, Vol. 91, No. 6, November-December, 1948, pp. 12–14, illus.

A review of the development of supersonic wind tunnels and supersonic aerodynamic theory. It includes description of the $2^1/_2$ in. flexible-nozzle supersonic wind tunnel of the California Institute of Technology and the 15 by 20 in. tunnel built at the Aberdeen Proving Ground of the Ordnance Department, U.S. Army.

Wartime Aeronautical Research & Development in Germany. II—The Aerodynamic Research Establishment at Göttingen. J. J. Green, R. D. Hiscocks, and J. L. Orr. *The Engineering Journal*, Vol. 31, No. 11, November, 1948, pp. 584–589, illus., diagrs., figs.

Laboratories, wind tunnels, and test facilities of the various research divisions. Projects under investigation included: the behavior of high-speed wings at low speeds; boundary-layer control by suction and by blowing; swept propeller blading, ducted propellers; boundary-layer transition and low-drag airfoils; the development of pressure- and temperature-measuring instruments, strain gages, accelerometers, and air-speed meters; wind-tunnel design and instrumentation; and the development of axial-flow compressors.

I.A.S. Seventeenth Annual Meeting

(*Continued from page 45*)

hibitively expensive. Eight displays were evaluated, five of which are already in existence. These were: (1) The C.A.A. indicator, (2) The Airline Indicator, (3) The Air Force Indicator, (4) Walter Grether's indicator, and (5) The Radio Magnetic Indicator. The three new displays were called Pictorial A, Pictorial B, and Pictorial C. The first five are symbolic displays and present separate pieces of information in the form of numbers in windows, dial readings, needle deflections, etc. Using this information the pilot must compute the solution to the navigation problem with which he is faced. The last three displays are primarily pictorial or graphic, because the actual spatial relations pertinent to his position with respect to the VOR station are reproduced in miniature on the face of the display offering the pilot the possibility of a perceptual solution of the problem. To measure how well their pilot subjects could use these displays, they first made up a series of ten navigation problems based upon different positions and headings of the aircraft with respect to a VOR station. The problems called for various representative tasks such as to fly to, or sometimes away from, the station along a track through the present position of the aircraft, etc. For a solution the pilot had to choose from a multiple response. The pilot group was composed of 16 noninstrument pilots, 16 commercial pilots with instrument rating, and 16 schedule air-line pilots. The instrument and air-line pilots made fewer errors than the noninstrument pilots, but there was no significant difference in time scores. With respect to both time-and-error scores there were significant differences between displays, similar differences being found for all groups. Perhaps the most important result of the investigation was that so-called pictorial displays were superior to the symbolic displays. Such a result may have wide application.

P. J. Rulon (Educational Research Corporation) spoke of an important topic "Psychological Factors in the Recognition and Avoidance of the Inadvertent Stall," and Dr. C. P. Seitz (Navy Special Devices Center) described a fine laboratory and well-developed research methods in his paper on "The Research Program of the U.S. Navy Special Devices Center on Human Problems in Flying."

BREAD... so millions may live!

Out of a Berlin bakery, this German child trundles bread made from flour flown in by American pilots in Douglas planes.

A marvel of modern mass transportation, the Berlin Air Lift was made possible through the courage and efficiency of Air Force personnel, *plus* the foresight and creative skills of Douglas craftsmen and engineers. For, ready to meet this need—as they were ready to meet the needs of war—were fleets of Douglas DC-4s (Army C-54... Navy R5D) —backbone of the Air Lift.

Realizing the vital importance of *dependable* air transport—both military and commercial—Douglas continues to pioneer new transport models. Now under construction is the new DC-6A air freighter capable of flying loads up to 30,000 lbs. at 300 mph. Future operations, utilizing the DC-6A, will require half as many planes, three-fourths the men, and reduce operating costs one-third, compared with present Berlin Air Lift requirements.

DOUGLAS AIRCRAFT COMPANY, INC.

Aeronautical Reviews

Books

Mechanics

By J. P. Den Hartog. New York, McGraw-Hill Book Company, Inc., 1948. 462 pp., illus., diagrs. $6.50.

A critical review of this new book by Professor Den Hartog is a pleasant but difficult task—pleasant because of the author's interesting entertaining style of writing; difficult because, judging by ordinary standards, there is little that can be seriously criticized. The author has cleverly pointed out in the preface that Newton's third law (action equals reaction) applies to people who criticize! This review will therefore be conducted with unusual care.

As explained in the preface, this is "a textbook designed for a two-semester course for sophomores or juniors in a regular four-year engineering curriculum." Such a book is of primary interest to educators and must therefore be evaluated from that point of view. This reviewer, not having taught the particular course involved, must base his comments on two kinds of experience: (1) some 20 years of working with and supervising college graduates in an engineering department, and (2) recent experience in teaching Strength of Materials, a course that follows Mechanics. In both cases it has been possible to observe the results of the teaching methods used in presenting Mechanics to the student.

The usual questions about a book of this type can be disposed of quickly. In content, arrangement, problems, and mathematics there is no marked departure from other standard texts. Calculus is used freely; the problems are interesting and appear to be adequate in scope. It is clear that the author has had many years of experience in teaching the subjects involved. There are a few minor points that might be improved. For example, on page 57 numerals are used to denote the joints in a truss. As a result the vector diagrams bear what appear to be numbers but really are not. Since it is often convenient to indicate the magnitude of a vector by a number placed alongside of it, the use of letters for truss joints would be preferable.

It is encouraging to see an increasing use of vectors to represent moments (or couples). In this book the double-headed arrow is used to distinguish the moment vector from the force vector. On this point many engineers seem to have had little or no training, perhaps because moments were treated primarily as bending moments "in the plane of the paper."

Turning now to a more general evaluation of the book, it becomes apparent that any further criticism will apply, in some degree, to almost all existing textbooks covering this same field. The only serious question, then, is whether a new book of this type should not have departed more radically from accepted methods and concepts.

To be specific, take the first figure in the book, the "parallelogram of forces." In presenting this construction, the author emphasizes "that it is an axiom not provable by logic from known facts." It seems important, in establishing the foundation for the analysis of forces, that we go as far back as possible to something which is *instinctively* recognized as being true. What could be simpler than vector addition, in which quantities having both magnitude and direction are represented by lines (arrows) in space, which are then "added" by placing the tail of one arrow against the head of another? This is something that a child does when he "adds" building blocks. This action gives us the so-called triangle of forces, which is only half of the parallelogram. Den Hartog, like practically every other author, treats the triangle as a result of the parallelogram method, in which "not all the lines have to be drawn in the figure." Perhaps the parallelogram method has served long enough (350 years) as a basis for statics; it seems more logical to use it as an experimental proof of vector addition.

If vector addition is accepted as a starting point, it is only necessary to state that such addition takes care of *magnitude* and *direction* only. *Moments* of forces represent another problem. Furthermore, vector addition is entirely sufficient in dealing with the moment vectors. It may be significant that the first thing that is done in extending the parallelogram construction to multiple forces is to replace it by the *polygon of forces*, which is pure vector addition.

The next step that seems desirable is to start working directly with forces in *space*. We live in three-dimensional space but unfortunately have to write and draw on two-dimensional paper. This, of course, has had a profound effect on our teaching methods. In the present book, space forces make their first appearance in Chapter VII (page 102) *after* such subjects as distributed loadings, hydrostatics, trusses and cables, beams, shear, bending moment, and friction. Thirty pages later (Chapter VIII) the Method of Work is taken up, and the treatment of space forces ends, except for a few special applications in the latter part of the book. Since most of our Mechanics texts follow this general pattern, it is easy to understand why the engineer usually finds it difficult to deal with three-dimensional problems.

We might well borrow an idea from teachers of music, who devise special exercises for the weak fingers. Certainly, if the student has a clear mental picture of events in three-dimensional space, he will find it easy to deal with the special cases of plane problems. This does not mean that the entire book has to be written on a three-dimensional basis, because it is true (fortunately) that many problems are two-dimensional or can be reduced to this status.

Along this same line, almost all mechanics texts use the beam as a basis for the treatment of what we call "shear" and "bending moment." Although the beam represents the most common application, the principles involved are those of summation and resolution of forces into resultant forces and moments at specified points and with reference to prescribed axes. In an airplane wing, for example, it is customary to sum up all loads from the tip inboard, with reference to an arbitrary set of axes which, in general, do not coincide with any "beam" or "shear" member. At any given section through the wing structure, these resultants must then be transferred to certain axes representing the centers of resistance of the structure with respect to shear, bending, and torsion.

For information on I.A.S. Library Service Facilities, see page 49

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

The present book treats this subject briefly and in a rather elementary way under the heading "Straight and Curved Beams" (pages 127–132). Some books have neglected it entirely. Here again we seem to have the cart before the horse. The terms "shear" and "bending" actually refer to a type of internal action in a structure, and it is unfortunate that they have been adopted also to refer to resultant (collected) loads and moments. This undoubtedly accounts for some of the confusion that is frequently encountered in the treatment of swept-back wings, tapered beams, and curved structures.

Another source of confusion, well known to every teacher and structures engineer, comes from the systems we have invented for indicating the sense of loads and moments. If Statics were presented to the student only as a study of forces, without any reference to their internal effects, this trouble would be eliminated. For example, Professor Den Hartog defines a bending moment as "positive when it causes a compressive force in the top fibers and a tensile force in bottom fibers of the beam." No wonder this well-known system confuses the student. It involves first a reference direction with respect to gravity ("top") and then another convention with respect to the internal behavior of the material ("compressive"). When the beam is rotated through a right angle the system becomes meaningless. This, incidentally, reveals the strong influence of civil engineering, in which the majority of beams are loaded by gravity.

The above convention for the sign of the bending moment has been replaced, in many structural textbooks, by a "space" type of convention (in which a clockwise moment is established as either positive or negative). A short section of a beam, when shown in equilibrium, must then have moments of opposite sign acting on opposite ends. This is confusing to the student who has been taught the old way, but it agrees entirely with the law of "action equals reaction," or $\Sigma M = 0$. The same reasoning applies to shear conventions, where the equilibrium conditions are given by $\Sigma P = 0$.

As a concrete example of the situation that exists today, it is possible to pick up two modern textbooks that include the Hardy Cross moment distribution method and find that one uses a positive and the other a negative "carry-over" factor. It would seem logical to use only the "space" system in mechanics texts; in fact there is no real reason why this system cannot be adopted for all structural problems. The two important points for the student to grasp are: (1) a negative sign obtained from an algebraic solution indicates that the force in the particular member is of opposite sense to that originally assumed; (2) the summation (or integration) process must always proceed in the same direction (i.e., "cut" sections must always be viewed from the same direction).

A common complaint about engineering graduates, especially in structures, is that they do not seem to have a clear grasp of fundamentals, especially in tackling new or unusual problems. One possible reason for this might be the tendency of most authors to perpetuate certain "laws" and "theorems" (with proper names and dates attached) long after they have become more or less obvious results of more basic laws or postulates. For example, in the present book (page 14) we find the "theorem of Varignon (1687), which states that "*the moment of a force about a point is equal to the sum of the moments of the components of that force about the same point.*" Two hundred and sixty-two years ago this was unquestionably an important theorem. Today it would seem to be a necessary consequence of the definition of components, something that *must* be true if the effect of the components is to be exactly the same as that of the force they represent. It would seem desirable to reduce the number of "theorems," proper names, and dates to an absolute minimum, in order to emphasize the laws that are truly fundamental. (Footnotes could be used if the historical flavor must be retained.)

The student's grasp of basic laws would be improved if the word "law" were more sparingly used and if more emphasis were placed on the true laws of nature. For instance, the heading of Section 56 contains "Coriolis' Law." It is subsequently referred to as "Coriolis' theorem." Later the term "Coriolis acceleration" is said to be "named after its inventor, Coriolis (1792–1843.)" Also used are "Coriolis term," "Coriolis components," Coriolis force," "theory of Coriolis," and "Coriolis effect." After all this the student must really believe that Coriolis did invent this phenomenon, which is simply an inevitable consequence of Newton's law of motion. But, according to page 295, "Newton's law is true for coordinate systems at rest; in general it does not hold for moving coordinate systems." The author could not have meant this literally, for Newton's law is used in deriving the Coriolis acceleration. The most important thing the student should learn from this is that the principle of superposition does not hold for accelerations when rotation is involved. (The principle of superposition does not seem to be mentioned, as such, in the text.)

Most of the foregoing remarks are directed toward the basic problem of education. Whether or not they constitute a serious criticism of Professor Den Hartog's book will depend on the point of view of the reader.

F. R. SHANLEY
Consultant
The Rand Corporation

Faithful as a
following shadow
The Kollsman Synchrotel Transmitter is a "brain" which directs muscles into action for precise remote control as a function of altitude, air speed, Mach number, vertical speed, acceleration. Synchrotel has jewel bearings, no brushes, and a lightweight rotor permitting smooth, velvety action and immediate response like a following shadow. Synchrotel may function as a control transformer, an inductive pick-off, resolver or signal generator. Typical applications: automatic pilots, flight recorders, altitude controls for air traffic separation, bomb and gun sight computers, telemetering, etc. Write for additional data on this unique unit. Address: Kollsman Instrument Division, Square D Company, 80-08 45th Avenue, Elmhurst, New York.
KOLLSMAN AIRCRAFT INSTRUMENTS
PRODUCT OF
SQUARE D COMPANY
ELMHURST, NEW YORK
GLENDALE, CALIFORNIA

Supersonic Flow and Shock Waves

By R. Courant and K. O. Friedrichs. New York, Interscience Publishers, Inc., 1948. 464 pp., diagrs. $7.00.

The Applied Mathematics Panel of the N.D.R.C. published in 1944 a confidential report entitled *Supersonic Flow and Shock Waves*. This report was prepared by the Applied Mathematics Group at New York University under the leadership of R. Courant and K. O. Friedrichs. Most workers in the field of fluid mechanics and shock waves know this report under the title *Shock Wave Manual*.

The present book represents the enlarged, improved and polished version of this manual. The material of the book is organized under six broad headings. It begins with a chapter entitled "Compressible Fluids" in which the thermodynamical and dynamical equations of motion are derived and discussed. A chapter entitled "Mathematical Theory of Hyperbolic Flow Equations for Functions of Two Variables" follows, where the fundamental concept of characteristics is introduced and applied. The hodograph transformation and the singular curves encountered in this transformation—i.e., limiting lines and branch lines—are discussed. The third chapter, "One-Dimensional Flow," deals with flow fields that depend on only one space coordinate. The subject here includes wave propagation, wave interaction and also detonation and deflagration processes. The concept of a shock wave is introduced here.

Chapter IV treats, then, the case of steady flow depending on two space variables. Here, the hodograph transformation is taken up again, and stationary shock waves and their reflection and interaction are treated. The small perturbation theory for two-dimensional supersonic flow is briefly touched upon. Chapter V deals with flow in nozzles and jets. The Laval nozzle theory and the construction of parallel flow nozzles are taken up here. Chapter VI, entitled "Flow in Three Dimensions," gives a brief outline of supersonic flow past slender bodies of revolution and of the rigorous solution for flow past a cone followed by a more extensive section on spherical waves.

Some subjects that do not directly fit in with the chapter titles are included in appendixes. For example, the analogy of compressible fluid flow and the motion in shallow water is included in an appendix to Chapter I. The interesting theory of waves in elastic-plastic materials is given in an appendix to Chapter III, etc. The book closes with a fairly extensive bibliography containing some 198 references. The general organization is much the same as the *Shock Wave Manual*, but the subject matter has been expanded almost everywhere. Changes in the

IN THE AIR . . . OR IN SERVICE DEPOTS
with
AMPHENOL "AN" Type CONNECTORS

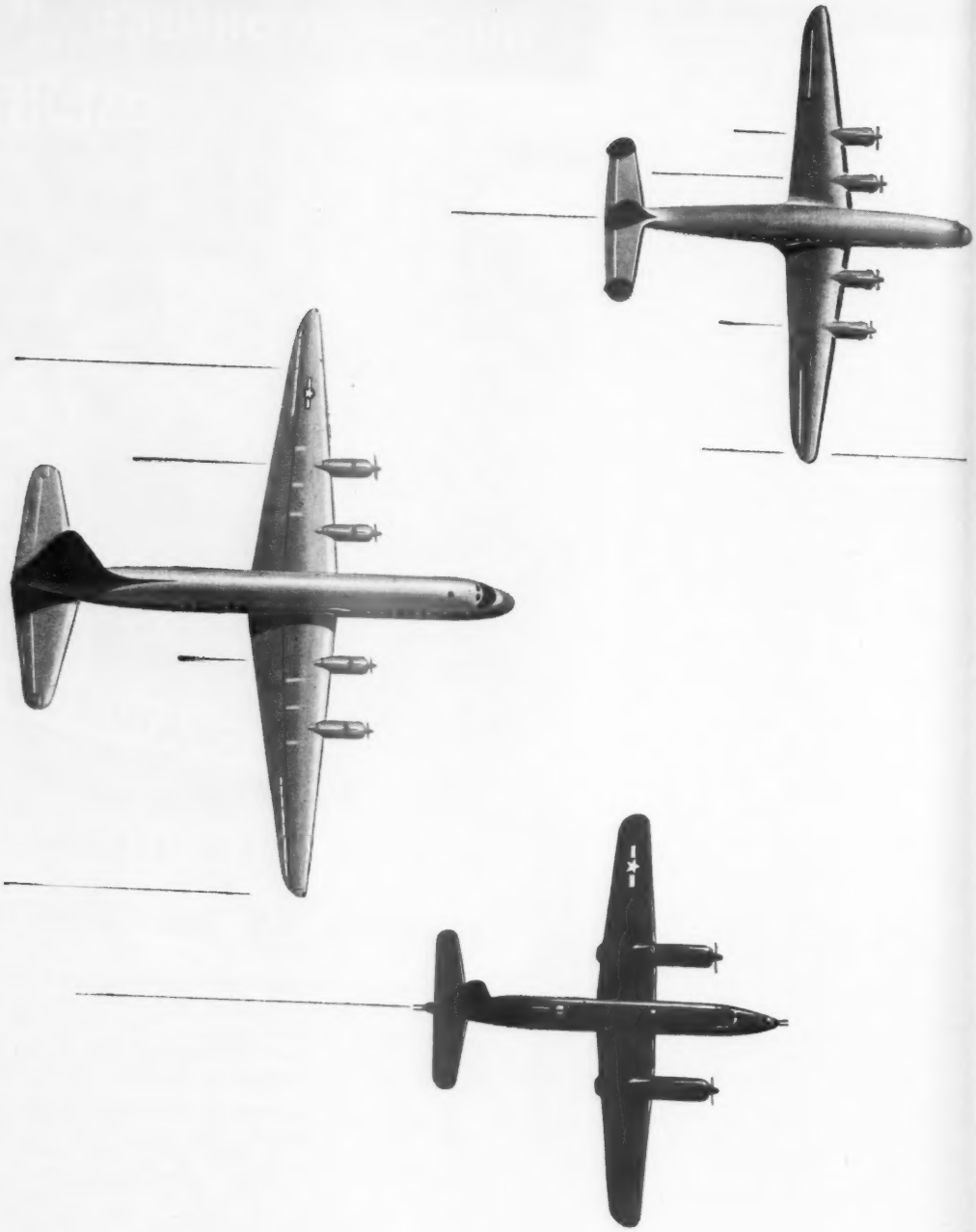
The aircraft industry demands dependable, quickly serviceable and simplified installation in electrical and communication circuits . . . Amphenol "AN" connectors provide that efficient detachable connection that makes fast, dependable service possible.

In a matter of seconds faulty radio or radar equipment can be replaced while plane is in the air. It's the positive-contact, quick disconnect feature that saves time . . . *insures* easy installation and fast changeover, of critical importance in the aircraft industry. Anodizing and other special finishes are used for protection from corrosion . . . extra heavy cross sections withstand the most rugged operating conditions.

Amphenol engineers and technicians are available without obligation to assist in specifying the right type of "AN" connectors for use in instrument power and control circuits.

AMPHENOL *Amphenol Serves the Aircraft Industry*

AMERICAN PHENOLIC CORPORATION
1830 SO. 54TH AVENUE
CHICAGO 50, ILLINOIS



All the Leaders are Lockheeds

All current Lockheed planes have set official world records.

The Lockheed Constitution has carried more people farther—nonstop—than any other operational transport (90 persons 2,557 miles).

The Lockheed F-80 Shooting Star set the world's official speed record for crossing the continental United States (2,445 miles in 4 hours, 13 minutes).

The Lockheed Constellation broke the official transport speed record—after four years of commercial service—by crossing the United States in 377 minutes.

The Lockheed P2V Neptune has flown a greater distance nonstop than any other plane in the world (11,236 miles—from Perth, Australia, to Columbus, Ohio).

Lockheed

AIRCRAFT CORP., BURBANK, CALIF.

Look to Lockheed for Leadership

Copyright 1949, Lockheed Aircraft Corp.

presentation and in the figures have made the book much more readable than the report.

The book deals with nonviscous and nonheat-conducting fluids so that boundary-layer effects, skin friction, and heat transfer are not included. Little space is devoted to the linearized theory of supersonic flow and to transonic flow problems. The authors are mainly interested in nonlinear problems; the omission of details and applications of linearized theory is therefore understandable and hardly a fault, since there exist a large number of recent reviews on linearized flow theory. Transonic flow, however, is strictly a nonlinear problem and thus would fit well within the scope of the book. On the other hand, in spite of a fair number of papers on this subject, there does not seem to exist a consistent theory of steady transonic flow, and a thorough treatment of this problem may well be kept back for future editions.

The outstanding characteristic of this book is the emphasis on the nonlinear character of the flow. In this respect it differs greatly from the standard approach to compressible fluid flow. A second exceptional quality of this book is the fact that it presents rigorous mathematics without an overload of pure formalism, so that in spite of the rigor the book remains readable; it is possible to read with benefit a chapter without having to work through each page in detail. The careful and competent handling of the relations between the mathematics and physics of the flow problems makes this possible.

The aerodynamicist should not expect to find here an easy approach to his daily problems. Instead he has here a text in which the solid foundations are given upon which any approximate treatment for practical problems and computational procedures will have to rest. He will find here also the mathematical approach to the construction of flow fields by means of the characteristics and discussions about the initial and boundary value problems that arise in supersonic flow; this is one subject that is not often presented in the aeronautical literature with sufficient care.

Supersonic Flow and Shock Waves represents one of the few books in mathematical physics dealing almost exclusively with nonlinear phenomena. To the reviewer's knowledge it is actually the first book where a systematic approach to nonlinear waves is applied to a large number of special problems. It is dangerous to prophesy, but with the present trend in physics one cannot help drawing the parallel to Courant and Hilbert's *Methods of Mathematical Physics* which appeared in 1924, preceding an epoch in physics for which it furnished, for some time at least, the mathematical tools.

PROF. H. W. LIEPMANN
California Institute of Technology

Airport Management

By John H. Frederick. Chicago, Richard D. Irwin, Inc., 1949. 316 pp., illus. $4.00.

This is a practical textbook for airport managers as well as airport engineers. It presents a well-coordinated treatment of airport management problems and stresses the fact that, while every airport possesses a certain individuality reflecting the community, its location, and the type of service it provides, there are many things common to all airports which can be similarly handled.

The author states that it is part of airport management's job to convince everyone that an airport is an integral part of any community, that aviation is a business, and that an airport is a facility that must be "tailored" to the region it is designed to serve.

This book emphasizes, and rightly so, that airport management should start with the engineering and planning of the airport to assure its eventual success financially.

The chapters on approach zoning and airspace rights, airport financing and airport management, reflect the author's well-grounded knowledge of the subject. He is, perhaps, too critical of the attitude of the scheduled air carriers with regard to airport charges and should have stressed the effects of air transportation on community growth and the benefits derived from air service to a greater degree.

The controversial subject of gasoline and oil sales at airports is well presented and should promote intelligent discussion, although some of the views expressed do not meet with the reviewer's opinions.

The practical treatment of airport income from nonaeronautical activities deserves the attention of everyone charged with the development of landing facilities, whether it be planning engineering management or administration.

The comprehensive Airport Check Lists at the end of the book form a useful complement to the coverage given every phase of airport management.

Apart from the authoritative background and information which will be found within the covers of this book, the outstanding impression gained from reading *Airport Management* is the clear and concise manner used in presenting the subject matter. This book should provide a ready reference for every airport manager.

CHARLES FROESCH
Chief Engineer
Eastern Air Lines, Inc.

Combustion Engines

By Arthur P. Fraas. New York, McGraw-Hill Book Company, Inc., 1948. 439 pp. $5.50.

This book, being an introduction to the theory and design of internal com-

bustion engines, is intended for the use of engineering students who have had little or no background in the subject. The book is well written but incomplete, as might be expected in attempting to cover such an exhaustive subject in slightly more than 400 pages. Subject headings include cycle analysis, both ideal and actual; thermodynamics; combustion, carburetion, manifolding, and supercharging; ignition, fuels, lubricants and lubrication, and cooling, together with chapters on the gas turbine; overhaul and maintenance. The text would be more complete with respect to the basic subject of theory and operation of piston type engines if the chapters on the gas turbine and overhaul and maintenance had been omitted in favor of material on cylinders and pistons, valve gear, and the crank system, since there is only a casual reference to these important elements in the text.

The subject matter throughout the book is up to date, the author having drawn heavily on N.A.C.A. reports and S.A.E. and A.S.M.E. articles for the past 10 years in presenting data on subject headings covering components, while Keenan's *Thermodynamics* provides the framework for the chapters on Cycles and Thermodynamics. The use of the Keenan and Kaye air tables and Hottel's combustion charts is explained in the discussion of properties of the working fluid.

P. B. TAYLOR
Partner
Sanderson & Porter

Mechanical Vibrations

By W. T. Thomson. New York, Prentice-Hall, Inc., 1948. 222 pp., diagrs. $5.00; $3.75 to schools.

Teachers of mechanical vibration will welcome the new addition of a well-written textbook by Prof. W. T. Thomson, of the University of Wisconsin. The book consists of eight chapters: introduction; undamped free vibration with single degree of freedom; damped free vibration with single degree of freedom; forced vibration with single degree of freedom; systems with two degrees of freedom; systems with many degrees of freedom; vibration of elastic bodies; and electromechanical systems and analogies.

The reader is assumed to have an elementary knowledge of calculus, dynamics, and strength of materials. Such topics as Fourier series and solution of differential equations are adequately presented in the text.

The book was written as a textbook for an introductory course, presumably more in the undergraduate level, and, indeed, for that purpose it will fit in very well. Also, with this purpose in mind, it is to be expected that no advanced topics are included. However, the writer is to be congratulated for his clear presentation of many methods suitable for the more advanced problems in an elementary manner, such as Rayleigh's method, Stodola's iteration process, Holzer's analysis, the effective inertia method, Myklestad's tabular method, and Dunkerley's approximation. Many numerical examples are included throughout the text to illustrate the methods of analysis.

It is a pleasure to note that the writer has placed particular emphasis on rational analysis developed from basic fundamentals.

DR. C. T. WANG
Associate Professor of
Aeronautical Engineering
College of Engineering
New York University

Book Notes

AERONAUTICS, GENERAL

The New Book of Flight. Edited by C. H. Gibbs-Smith. London and New York, Oxford University Press, 1948. 288 pp., illus. $5.00.

This volume provides a survey of modern aeronautics by British specialist writers, including chapters on Rocketry, Jet-Propulsion and the Gas Turbine, Helicopters, Airships, Radar in Aviation, Flight Refueling, Pioneers, The British Empire's Contribution to Aviation, British Air Transport, Careers in the R.A.F., Naval Flying as a Career, Careers in the British Aircraft Industry, The Royal Aeronautical Society, Aeromodelling, and Air Stamps of the Empire. The reference section includes a chronology to 1909, pictures and brief data on about 275 of the world's current aircraft, a bibliography of about 125 books and 50 periodicals, and twelve selections from the literature of flight, ranging from Lana's prophecy of air war to quotations from recent books and magazines.

AIR TRANSPORTATION

Airline Record, 1948 Edition. Chicago 4, Ill., 208 LaSalle Street, Roy R. Roadcap, 1948. 111 pp., maps, charts. $7.50.

This useful compilation includes data on 24 air lines, the securities of which are held by the public. For each air line is given a route map; a brief history; data on property and equipment, officers, and directors; revenue traffic statistics for the calendar years 1941 through 1947; and, for this same period, tabulations of income accounts, pay load and income account analysis, balance sheets, and capitalization and financial ratios. For older air lines, a brief historical financial summary is also tabulated for the period before 1941. A useful explanatory introduction contains full notes on the terms used, their statistical basis and commonly accepted values, with indications of dates of changes in statistical reporting by the air lines to the Civil Aeronautics Board. Maps of international and domestic routes, traffic charts, and traffic and financial data for the industry are summarized in the first part of the book.

AIRPORTS & AIRWAYS

The Airport Directory. New York, The Haire Publishing Co., 1948. 280 pp., maps. $3.00.

This 1948 edition describes over 8,000 airports in the United States and about 270 Canadian airports. About 450 United States seaplane bases are described in chart form. An airport map is provided for each state. Additional information includes lists of U.S. Weather Bureau offices, state aviation boards and commissions, radio facilities, cities served by air lines, aviation distributors, aviation equipment manufacturers, and summaries of state gasoline taxes.

AVIATION MEDICINE

Aviation Medicine in Its Preventive Aspects, An Historical Survey. John F. Fulton. (University of London, Heath Clarke Lectures, 1947.) London and New York, Oxford University Press, 1948. 174 pp., illus., diagrs. $3.50.

Dr. Fulton states in his preface that the five topics in this volume were selected on the basis of familiarity and that this volume is a historical survey of some of the more important developments in the field rather than a review of the entire subject. Students of the history of aviation medicine will be grateful for the selection of topics made and for the thorough scholarship with which the development of each is explored. If the history of aviation medicine requires a new interpretation and correlation of matters of record in the light of one of the great technological advances of our time, this book has fulfilled that requirement for all the topics chosen. The historian's job of collecting and putting under control a great deal of scattered data has been accomplished at the same time, both in the exactly written and readable text and in the useful bibliographies appended to each lecture. An excellent index of names and subjects is provided. The topics of the lectures are as follows: "Altitude Sickness and Acclimatization: The History of Oxygen"; "Decompression Sickness: The Genesis of the Tissue Bubble"; "Pressure Cabins and Explosive Decompression: The Spring of Air"; "Effects of Acceleration: Dim-Out and Black-Out, Protective Measures"; "Man and the Machine: Problems of Safety in Flight." Dr. Fulton is the Sterling Professor of Physiology at Yale University.

ELECTRONICS

Advances in Electronics. Volume I. Edited by L. Marton. New York, Academic Press, Inc., 1948. 475 pp., illus., diagrs. $9.00.

Ten critical and integrated reviews of specific topics in the field of physical electronics and in selected fields of engineering electronics are presented in this volume, with a general emphasis upon fundamental progress rather than upon the accessories. References are included with all the essays except the final one, a total of more than 660 references being given. Author and subject indexes are provided. Contents: Oxide Coated Cathodes, Albert S. Einstein; Secondary Electron Emission, Kenneth G. McKay; Television Pickup Tubes and the Problem of Vision, A. Rose; The Deflection of Beams of Charged Particles, R. G. E. Hutter; Modern Mass Spectroscopy, Mark G. Ingrahm; Particle Accelerators, M. Stanley Livingston; Ionospheric Research, A. G. McNish; Cosmic Radio Noise, Jack W. Herbstreit; Propagation in the FM Broadcast Band, Kenneth A. Norton; Electronic Aids to Navigation, J. A. Pierce.

Industrial Electronics and Control. Royce Gerald Kloeffler. New York, John Wiley & Sons, Inc., 1949. 478 pp., illus., diagrs. $5.50.

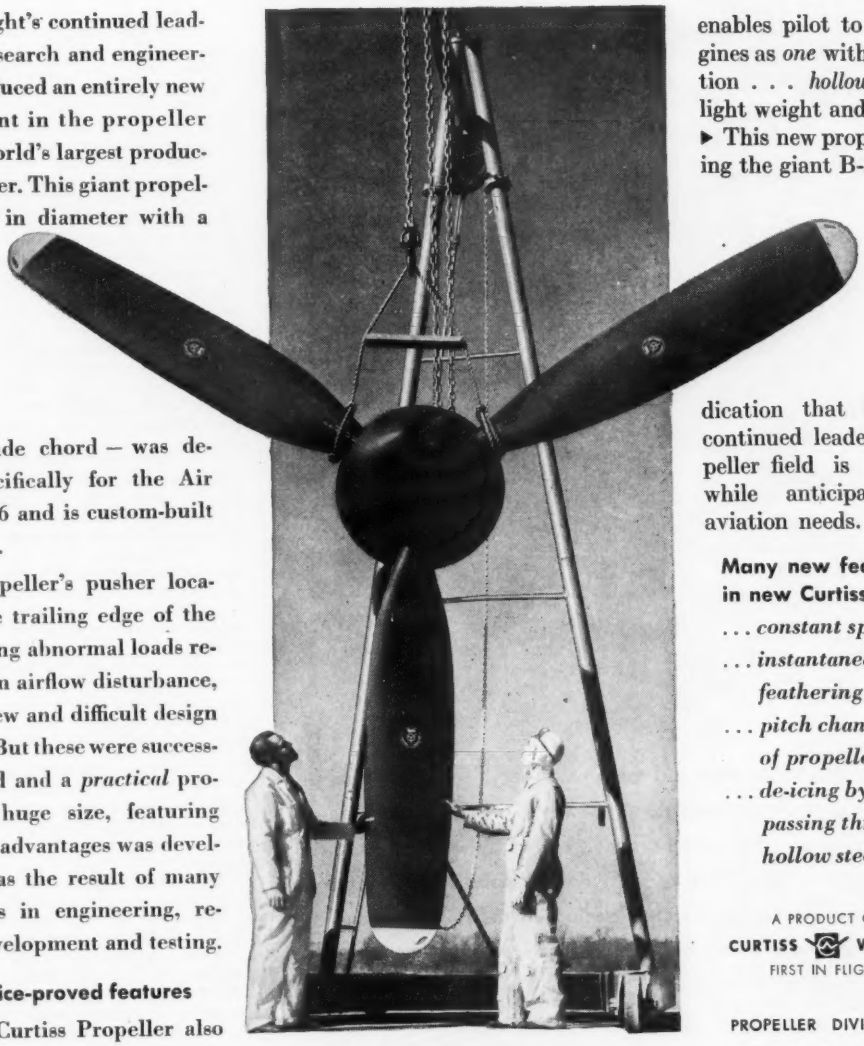
Designed as a textbook for electrical, mechanical, and chemical engineering students, the emphasis in this book is upon industrial and commercial applications of electronics. The first five chapters can be used as an introduction to the theory of electron tubes. These are followed by chapters on Gaseous and Vapor Electron Tubes, Photoelectricity, and Crystal and Metallic Rectifiers. About 60 per cent of the book is concerned with the major applications of electronics in industry, including principles of control and servomechanisms, high-frequency heating, resistance welding, electronic operation of d.c. motors, photoelectric control devices, electronic regulators and power controls, amplidyne servomechanisms, and x-ray and special photo applica-

ANNOUNCING WORLD'S LARGEST PRODUCTION PROPELLER

"Custom-Built" BY Curtiss-Wright

FOR THE B-36

Curtiss-Wright's continued leadership in research and engineering has produced an entirely new development in the propeller field—the world's largest production propeller. This giant propeller—19 feet in diameter with a 21-inch blade chord — was designed specifically for the Air Force's B-36 and is custom-built throughout.



▸ This propeller's pusher location on the trailing edge of the wing, causing abnormal loads resulting from airflow disturbance, involved new and difficult design problems. But these were successfully solved and a *practical* propeller of huge size, featuring many new advantages was developed . . . as the result of many man hours in engineering, research, development and testing.

Many service-proved features

The new Curtiss Propeller also provides *reverse* thrust for smooth, air-cushioned landing and more effective braking . . . *automatic synchronization* which enables pilot to control *six* engines as *one* with single-lever action . . . *hollow steel blades* for light weight and extra strength.

▸ This new propeller now servicing the giant B-36 is another indication that Curtiss-Wright's continued leadership in the propeller field is meeting *today's* while anticipating *tomorrow's* aviation needs.

Many new features included in new Curtiss Propeller

. . . *constant speed in reverse*
. . . *instantaneous reversing and feathering*
. . . *pitch change from rotation of propeller*
. . . *de-icing by heated air passing through hub and hollow steel blade*

A PRODUCT OF
CURTISS WRIGHT
FIRST IN FLIGHT

PROPELLER DIVISION, CALDWELL, N. J.

CURTISS ELECTRIC PROPELLERS

tions. The author is head of the Department of Electrical Engineering at Kansas State College.

Microwaves and Radar Electronics. Ernest C. Pollard and Julian M. Sturtevant. New York, John Wiley & Sons, Inc., 1948. 426 pp illus., diagrs. $5.00.

The purpose is to provide a compact overall survey, broad enough to give a general view of the field and a background upon which further study of particular phases can be based. The first chapter outlines the necessary special knowledge of electromagnetic fields for an understanding of microwaves. No other introductory knowledge is required beyond elementary physics, an elementary knowledge of electron tubes, and 2 years of engineering college mathematics. Footnote references are included throughout, and author and subject indexes are provided. The authors are professors, respectively, of physics and chemistry at Yale University.

A Textbook of Radar. A Collective Work by the Staff of the Radiophysics Laboratory, Council for Scientific and Industrial Research, Australia. Sydney, Australia, Angus and Robertson; distributed by P. D. and Ione Perkins, South Pasadena, Calif., 1947. 579 pp., illus., diagrs. $13.00.

Contents: Introduction, E.G. Bowen; Fundamentals, J. L. Pawley; The Magnetron, D. M. Sutherland; Triode Power Oscillators, O. O. Pulley; Modulators, G. C. Dewsnap; Microwave Transmission and Cavity Resonator Theory, R. N. Bracewell; Transmission Line and Resonator Techniques, D. B. Fraser; Aerials, T. R. Kaiser; Aerial Duplexing, H. C. Minnett; Receivers, L. L. McReady; Local Oscillators, Joan M. Freeman; Frequency Converters, H. C. Minnett; Amplifiers, J. A. Fry; Display Circuits, B. Y. Mills; Automatic Ranging Circuits, B. F. Cooper; Radar Systems, V. D. Burgmann; Ground Radar, O. L. Wirsu; Shipboard Radar, G. P. Brown; Airborne Radar, L. U. Hibbard; Radar Navigation, M. Beard.

This book is suitable for graduate engineering students and for research engineers in industry. While it was written by the Staff of the Radiophysics Laboratory, set up in Australia in 1939 as a center of radar research in the Pacific area, it embraces the results of work done in England, the U.S., and Canada. Footnote references are given throughout to original reports and journals.

Waveforms. Edited by Britton Chance, Vernon Hughes, Edward F. MacNichol, David Sayre, and Frederick C. Williams. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 19.) New York, McGraw-Hill Book Company, Inc., 1949. 785 pp., diagrs. $10.

The purpose of this volume is to make available techniques that have been developed for radar timing and indicating applications, embracing developments made at various American and British laboratories. The applications of circuit techniques to the generation of waveforms, both sinusoidal and otherwise, and to the manipulation of waveforms to meet specific needs, are considered, *Waveforms* referring to currents of voltages as functions of time in a rectangular coordinate system.

Following an introductory chapter, two chapters deal with operations on waveforms with linear and nonlinear circuit elements. The next five chapters deal with the application of these basic elements to the generation of waveforms. Chapters 9 and 10 cover methods for analyzing a waveform with respect to amplitude or time, with emphasis upon the process of marking the instant of equality of two waves. The next four chapters deal with the methods of modulation and demodulation of most use in precision circuits, including operations with slowly varying voltages or mechanical signals. Chapters 15, 16, and 17 treat the basic aspects of the synchronization of waveform generators to accomplish frequency multiplication and division of sinusoids or pulses. Mathematical operations on waveforms are given in Chapters 18 and 19. Chapter 20 deals with the techniques used in the measurements of waveforms which can be carried out with a simple oscilloscope. The three final chapters treat Storage Tubes, Electrical Delay Lines, and the Supersonic Delay Device.

ENGINEERING PRACTICES

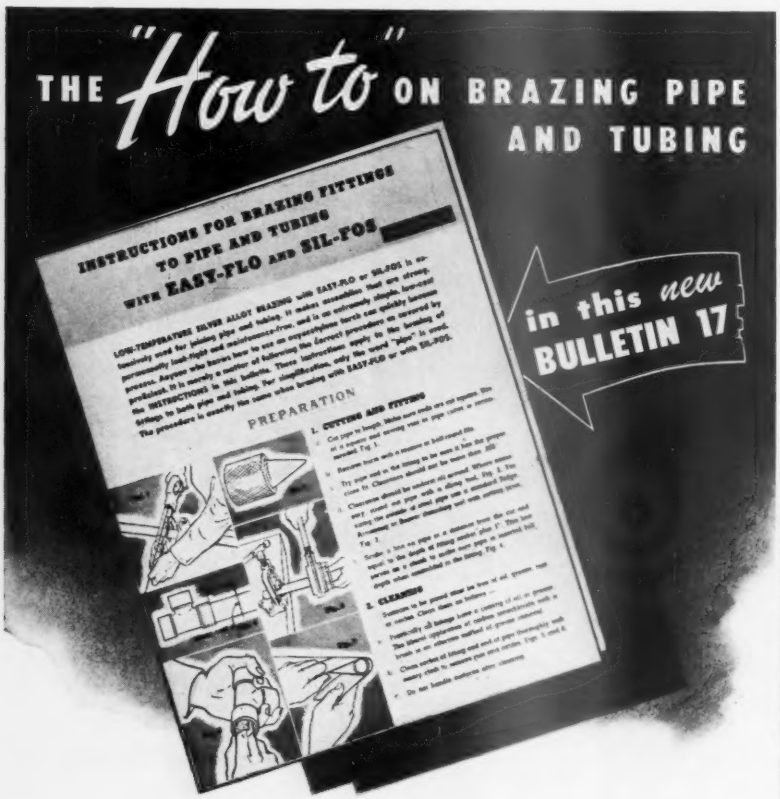
Triangulation Short-Cut Layouts. Joseph J. Kaberlin. Milwaukee, The Bruce Publishing Co., 1948. 290 pp., diagrs. $5.00.

The author's purpose is to provide a textbook and working guide for use in the study of modern triangulation methods in sheet-metal work. All types of sheet-metal pipes are considered, particularly for use in blower exhaust systems, heating, and air conditioning. Each of the 151 problems described is accompanied by two or more drawings, with arrows designating the direction each projection line should be drawn. Reference tables are included on materials and various useful conversions. The author is an instructor at the Washburne Trade School in Chicago.

EQUIPMENT, HYDRAULIC & PNEUMATIC

Hydraulic Machinery. Samuel R. Beitler and Eric J. Lindahl. Chicago, Irwin-Farnham Publishing Company, 1947. 217 pp., illus., diagrs. $3.50.

Assembled from notes used in teaching a course in hydraulic machinery to upper-class mechanical engineering students, this book covers a number of devices in order to give the student a general idea of what can be done with hydraulic machinery. Following introductory chapters on fluids and fluid flow, pipe and pipe-line flow are discussed, followed by chapters on fluid meters; inferential head meters; and Pitot tubes, weirs, and flumes. The second half of the book covers pumps, centrifugal pumps, hydraulic turbines and power plants, compressible fluid flow, and fluid drives. Professor Beitler teaches hydraulic engineering at the Ohio State University, and Professor Lindahl is head of the Department of Mechanical Engineering at the University of Wyoming.


THE "How to" ON BRAZING PIPE AND TUBING
INSTRUCTIONS FOR BRAZING FITTINGS TO PIPE AND TUBING WITH EASY-FLO AND SIL-FOS
in this new BULLETIN 17
PREPARATION

IF you do any brazing of pipe and tubing with EASY-FLO or SIL-FOS—or want to know just what the process is like you will find this new bulletin helpful. It gives the procedure, step by step, for—cutting and fitting—cleaning—fluxing—supporting assemblies—heating and flowing the alloys—cleaning after brazing. It tells how to make vertical up, vertical down and horizontal joints. Write today for a copy of BULLETIN 17.

HANDY & HARMAN

82 FULTON ST., NEW YORK 7, N. Y.

Bridgeport, Conn • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada

Agents in Principal Cities

GUIDED MISSILES

Glossary of Guided Missile Terms, prepared by the Committee on Guided Missiles. (G.M. 51/3.) Washington, The National Military Establishment, Research and Development Board, September 15, 1948. 72 pp.

Over 650 terms from reports and documents on various aspects of guided-missile work are defined. These include new words coined by the guided-missile art, words in general use but having different meanings in the guided-missile field, and a selection of general technical terms of use to those engaged in this field. The use of abbreviation and letter symbols is held to the minimum consistent with a clear and understandable word definition. The evaluation and selection of letter symbols is not attempted, as this is currently being undertaken for the various fields of science by the American Standards Association.

LAWS AND REGULATIONS

The Law of Aviation. Rowland W. Fixel. 3rd Edition. Charlottesville, Va., The Michie Co., 1948. 550 pp. $10.

The first edition of this treatise was published in 1927 and the second in 1945. This edition contains approximately 150 more pages than the last, including new sections on the role of the Comité International Technique d'Experts Juridiques Aériens (CITEJA) and the functioning of the Provisional International Civil Organization in the chapter on historical backgrounds, and new chapters on Military Aviation Law, Enforcement of Economic Regulations, Rules Governing Flight of Aircraft, and Bailments, Liens, and Attachments. Greatly extended chapters on Flight Procedures and Air Transportation replace older chapters on rules of the air and aircraft as a common carrier. U.S. War Department Circular No. 98, Assistance to Civil Aircraft (Domestic or Foreign) at Overseas Bases, is included as an additional appendix in this edition, and the Table of Cases includes about 40 per cent more cases. Chapters other than those already indicated have practically all been revised.

Inventions and Their Management. Alf K. Berle and L. Sprague De Camp. 2nd Edition. Scranton, Pa., International Textbook Company, 1947. 742 pp. $6.00.

This revised edition of a book first published in 1937 as a standard guide for inventors aims to cover the legal, technical, and business procedures to follow after an invention has been made. New material in this edition includes a discussion of the Lanham Act and the influence it will have on U.S. trademark law, and a new chapter on trends in industrial research and invention. A list of about 40 books, of libraries containing Patent Office publications, and of patent law associations, and a glossary of about 400 terms are included in an appendix.

MACHINE ELEMENTS

Kinematics of Machines. Arthur F. MacConochie. New York, Pitman Publishing Corp., 1948. 217 pp., illus., diagrs. $3.00.

This book is addressed to the needs of second- and third-year engineering students, preferably those studying concurrently a graphical course in mechanism. Following introductory chapters on Some Simple Machines in History, The Elements of Mechanism, and Geometry in Mechanism, the final two-thirds of the book are devoted to Velocity, Velocity in Mechanism, Acceleration, Acceleration in Mechanism, and the Kinematics of Simple Machine Elements. The concept of relativity of dimension and of time is introduced in the chapter on Velocity. The problems further reflect the author's point of view that engineering and physics are becoming more and more closely related and include applications in such fields as ballistics and rocket flight, as well as the more usual aeronautical and mechanical engineering problems. The author is a professor at the University of Virginia.

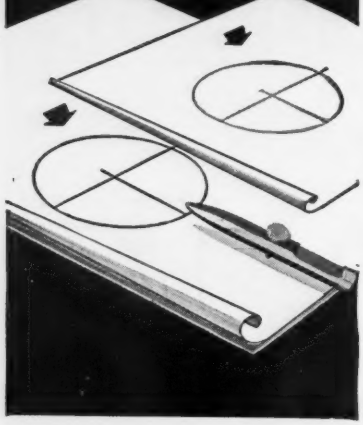
Machine Design. Paul H. Black. New York, McGraw-Hill Book Company, Inc., 1948. 357 pp., diagrs. $4.00.

Designed as a basic textbook for college courses in machine design and a reference work of modern practice, the emphasis in this book is placed upon the analytical method combined with the results of experimental investigation. A knowledge of mechanics, strength of materials, kinematics, mechanical processes, and engineering materials is presupposed. The discussion covers design methods of applying strength and deflection considerations, selection of materials, machine elements as fastenings, springs and translation, screws, and methods for designing and selecting power-transmission units and their components. New developments included are a complete treatment of stress concentration in machine members, methods of determining allowable stresses, including the effect of surface finish, the design approach to gear problems, and vibration and vibration control, with design and selection methods of vibrating-absorbing units. There are separate chapters on surface Finish Friction and Sliding Bearings and Lubrication. Footnote references are included throughout, and indexes of authors and subjects are provided. The author is a professor at Cornell University.

Machine Design Drawing Room Problems. C. D. Albert. 4th Edition. New York, John Wiley & Sons, Inc., 1948. 519 pp., diagrs. $5.00.

This edition of a textbook last revised in 1940 includes new chapters on graphical methods applied to determine the strength of gear teeth; hydramatic automobile transmission; the valve gear of a Diesel engine; allowable stresses and static and fluctuating loads; and worm gearing. Fifteen of the other 18 chapters have been revised. The general plan and purpose is to provide complete material for a drawing-room course in general machine design, using comprehensive problems rather than problems dealing with un-

Tracing cloth that defies time



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

IMPERIAL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

related details or groups of details. The author is emeritus professor of machine design at Cornell University.

MATERIALS

Magnesium, Its Production and Use. Ernest V. Pannell. 2nd Edition. London, Sir Isaac Pitman & Sons, Ltd., 1948. 189 pp., illus., diagrs. $4.00.

This edition of a book first published in 1943 contains new information available since the removal of wartime restrictions and published in the period 1943–1946. The first part, dealing with the pure metal, covers its general properties, sources, and methods for its commercial extraction. The second part, 131 pages, deals with alloys of magnesium and includes chapters on Alloy Compositions, Heat Treatment, Casting, Working, Corrosion and Protection, and Industrial Applications. Bibliographical references accompany each chapter.

METEOROLOGY

Weather Forecasting. S. W. Pack. London, New York, Longmans, Green and Co., 1948. 192 pp., illus., diagrs. $6.00.

The author's purpose is to present an introduction for students expecting to specialize in meteorology. The science of weather forecasting is explained in a practical and up-to-date manner, including chapters on recent developments such as tropical and long-range forecastings, and upper level charts. Mathematics is excluded except in a few instances, and extensive use has been made of explanatory diagrams. Appendixes include condensed international meteorological codes, a temperature conversion table whose lower range is −40°F., a table of relations between inches and millibars, and conversion tables of knots to miles per hour, meters per second, and kilometers per hour. The author is an instructor-commander in the British Royal Navy.

NAVIGATION

Navigation and Nautical Astronomy. Benjamin Dutton. 9th Edition. Revised by Alton B. Moody. Annapolis, Md., United States Naval Institute, 1948. 876 pp., illus., diagrs. $4.00.

This is a major revision and enlargement of the standard textbook, extensively rearranged and almost entirely rewritten. Among the new chapters are Electronic Navigation, Polar Navigation, and Lifeboat Navigation. The emphasis has been shifted to modern methods and from theory to practice. For example, the use of the maneuvering board has been brought into step with modern practice involving plotting boards, radar, and a combat information center; a summary of ocean currents has been included; instructions for the use of tide and current tables are more detailed; and time and the almanacs are incorporated into the text instead of segregated in a separate chapter. Problems are referred to the excerpts from the *Nautical Almanac*, 1947, but excerpts from the 1950 *Almanac* are included, with examples of their use.

PHOTOGRAPHY

Aerial Photography in Urban Planning and Research. Melville C. Branch, Jr. (Harvard City Planning Studies, No. 14). Cambridge, Mass., Harvard University Press, 1948. 50 pp., illus., diagrs. $3.00.

The first part of this study takes up the potentialities of greater use of aerial photographs in city planning by operating planning agencies and research organizations engaged in various phases of urban study. An analysis is made of the information obtainable by aerial photography and of practical considerations encountered by an operating planning unit, including available data on the cost of aerial surveys. The second part, comprising the greater part of the book, is devoted to the special knowledge required for the effective use of aerial photographs for city planning and research, covering the characteristics of different types of photographs, various methods of using them for particular purposes, photographic needs

FLIGHT DATA RECORDER

Flight Recorder 9921 is a continuous-strip recording instrument designed for use with Giannini end-instruments such as accelerometers, altitude transmitters, directional transmitters, etc.

Recently expanded manufacturing facilities afford firm delivery of 1949 improved instrument and powerplant equipment.

Latest Technical Catalogs on Request

G. M. Giannini & CO. INC.

285 W. Colorado, Pasadena 1, California
697 Morris Turnpike, Springfield, N. J.

G&O Radiators 34th Year

ENGINE COOLING RADIATORS

•

OIL COOLERS

The G&O Manufacturing Co.

NEW HAVEN, CONNECTICUT

and how to meet them, and problems of taking and processing the pictures. Discussion of the technical details of photogrammetry, camera equipment, and laboratory processing is kept to a minimum. Previous experience with aerial photographs is not assumed. Bibliographical and explanatory notes are included in a separate section.

POWER PLANTS, JET & TURBINE

German Gas Turbine Developments During the Period 1939–1945. British Intelligence Objectives Sub-Committee, Overall Report No. 12. J. W. Adderley. New York, British Information Services, 1949. 46 pp. illus., diagrs. $0.35.

This review of German gas-turbine work includes projects that were under development during the war, component design, materials, manufacture, test equipment, and administration of gas-turbine development. Appendix tables summarize the data on two power generation plants, four marine gas-turbine power plants, three gas-turbine plants for armored fighting vehicles, and 15 aircraft power plants. A list of about 60 references is included.

PRODUCTION

Precision Investment Castings. Edwin Laird Cady. New York, Reinhold Publishing Corporation, 1948. 356 pp., illus., diagrs. $6.00.

The author's aim is to present, for the practicing engineer, the resources and weaknesses of the "lost wax" or precision investment casting process, the predictable lines of its future development, and the practical methods by which the process may be operated soundly. The introductory chapters outline what the process is, what it does, and how it does it, including discussions of products cost in large, medium, and small quantities, economics of design, and comparison with other processes. The greater part of the book covers what must be done in product design and redesign to get the best results from precision investment casting and how to operate the process for maximum results. The wide variety of options in the process at every step is shown, with discussions of the limitations each option imposes upon the process.

Quality Control. Norbert L. Enrick. New York, The Industrial Press, 1948. 122 pp., diagrs. $3.00.

The author's emphasis in this manual is upon the practical application of scientific methods of inspection to manufactured products. How sampling plans and control charts are used and why they work in the shop are explained by the use of numerous examples with definite procedures and simple directions. New gaging practice with compressed limit gages, the basis of proper specifications, and the use of inspection data in establishing specifications are also discussed. The management aspects of quality control are outlined, followed by a typical case history and report on the results of a two months' quality control program. Two final chapters cover the statistical basis of modern quality control and the mathematical theory of control charts. The author was formerly with the Headquarters Quality Control Staff of the Quartermaster General's Inspection Service.

Motion and Time Study. Ralph M. Barnes. 3rd Edition. New York, John Wiley & Sons, Inc., 1949. 559 pp., illus., diagrs. $5.00.

The last revision of this standard work was published in 1940. The author has used the results of his recent survey of 80 factories to evaluate and present the most successful methods in general use. New material is included on process analysis, gang process charts, activity charts, man and machine charts, rating operators' performance, the effect of practice, and motion and time study programs.

Design of Industrial Exhaust Systems. John L. Alden. 2nd Edition. New York, The Industrial Press, 1948. 252 pp., diagrs. $3.50.

The author's purpose is to tell the engineer how to design or buy an exhaust system for such purposes as dust collecting, fume removal, and low-pressure conveying. Health hazards, industrial dusts, and the pathological phases of industrial hygiene are not discussed. The theory of airflow and its application to practical design, the selection of commercial fans and dust collectors, construction of the physical plant, and the testing of the completed system are discussed, with 120 accompanying drawings and diagrams relating to details of exhaust system design and tabulated design data. This new edition contains chapters on hoods for fume, smoke and vapor control and axial-flow fans, and a number of lesser additions reflecting advances and refinements in the field since the book was first published in 1939.

SCIENCES, GENERAL

Introduction to Engineering Problems. Robert Q. Brown. New York, Prentice-Hall, Inc., 1948. 191 pp., diagrs. $3.95.

The purpose of this textbook for beginning engineering students is to establish early training in thinking engineering problems through and to establish a closer bond between the contents of courses in mathematics, physics, and applied mechanics. Following an introductory chapter on objectives and general methods, the next 48 pages of the book deal with logarithms and the slide rule and some basic mathematical principles, including simultaneous and quadratic equations, right and oblique triangles, and significant figures and rounding off numbers. The section on basic physical principles takes up 93 pages. Final sections deal with good form in writing, including bibliographical form, engineering reports, equations, tables, diagrams and curves, letter reports, and letters of submittal. Four project problems are included at the end.

MATHEMATICS

An Essay Toward a Unified Theory of Special Functions, Based Upon the Functional Equation $(\partial/\partial s)\, F\,(s,\, a) = F\,(s,\, a+1)$. C. Truesdell. Princeton, N.J., Princeton University Press, 1948. 182 pp. $3.00.

Written from the point of view of the mathematician, the purpose of this essay is to present a particular branch of analysis, developed to provide a new method of deducing and proving formal relations among special functions. While some special functional equations reducible to the F-equation were studied in the eighteenth century by various classical mathematicians, and later by Bateman, a systematic treatment of these equations as a class and a unified theory of familiar special functions have not previously been presented. Many special functions are shown to be easily transformed into solutions of the F-equation by simple changes of variable; the resulting transforms satisfy numerous formal relations because they are such solutions. These include, as special cases, familiar and unfamiliar formulas, scattered through the literature of special functions and discovered in different ways by different persons, and other formulas that can supposedly be generally unknown. A bibliography of 68 titles is included.

MECHANICS

Mechanics. John W. Breneman. 2nd Edition. New York, McGraw-Hill Book Company, Inc., 1948. 144 pp., diagrs. $2.50.

Designed as a textbook for use in industrial training and engineering extension courses, this new edition is the first revision since publication in 1941. The original plan has not been changed, but numerous changes have been made in the text and some parts rewritten. A number of problems have been added and some older problems omitted. Material for the study of simple machines, gears, gear trains, pulleys and mechanisms, conditions of equilibrium in static structures, and on center of gravity and moment of inertia have been included, as in the first edition. The author is a professor of mechanics at The Pennsylvania State College.

PHYSICS

Principles of Mathematical Physics. William V. Houston. 2nd Edition. New York, McGraw-Hill Book Company, Inc., 1948. 363 pp., diagrs. $5.00.

This new edition of a textbook for junior, senior, and first-year graduate students is the first revision since its original publication in 1934. A number of changes have been made to clarify and simplify the discussion. New problems and more detailed solutions of numerous illustrative examples have been included. The chapters on electricity and magnetism in particular have been expanded, and additional material has been included on vibrating systems, the behavior of real pendulums with finite amplitudes of oscillations, and the motion of rotating bodies. The m.k.s. system of units has been used throughout.

Radiology Physics. John Kellock Robertson. 2nd Edition. New York, D. Van Nostrand Co., Inc., 1948. 323 pp., illus., diagrs. $5.00.

This revision of an introductory textbook for medical and premedical students and radiologists is the first since its publication in 1941. Developments in nuclear physics are incorporated into this edition, with rearrangement of the order of presentation and rewriting of various portions. The purpose of the volume remains the same, to provide a textbook for use in the latter part of a second-year course in physics, covering such topics as X-ray transformers, X-ray tubes, conduction of electricity through gases, radioactivity, nuclear physics, and high-frequency currents. The author is a professor of physics at Queens University, Kingston, Canada.

Supersonics, the Science of Inaudible Sounds. Robert Williams Wood. (The Charles K. Colver Lectures, 1937.) Providence, The John Hay Library, Brown University, 1939; Reprinted 1948. 162 pp. $2.00.

The original three lectures are here reprinted with a supplementary bibliography covering the period 1936–1947, of about 50 references. Professor Wood's lectures furnish a comprehensive survey of knowledge on the physical and biological effects of high-frequency sound waves as of 1937. The introductory lecture deals with the history of supersonics before World War I and with mechanical and electrical sources of inaudible sound.

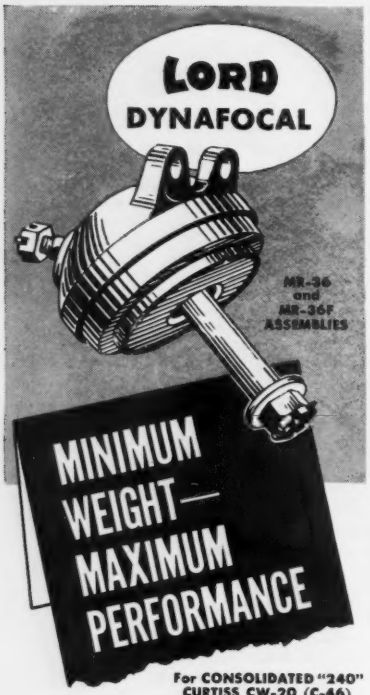
Vibration and Sound. Philip M. Morse. 2nd Edition. New York, McGraw-Hill Book Company, Inc., 1948. 468 pp., diagrs. $5.50.

This new edition of a textbook for students of physics and communications engineering, first published in 1936, contains over 100 more pages than the first edition. Considerable expansion has been made in the chapter on The Radiation and Scattering of Sound. The subject of transient phenomena and the technique of the operational calculus is introduced in the chapter on the Simple Oscillator, and the operational calculus is brought into other chapters. The order of presentation has not been changed, the introductory chapter being followed by chapters on The Simple Oscillator, The Flexible String, The Vibration of Bars, Membranes and Plates, Plane Waves of Sound, The Radiation and Scattering of Sound, and Standing Waves of Sound. A brief bibliography, a glossary of symbols, tables of functions, and computing diagrams are given in appendixes.

STRUCTURES

Analysis and Design of Airplane Structures. E. F. Bruhn. Revised Edition. Cincinnati 2, Ohio, Tri-State Offset Co., 1949. 483 pp. diagrs. $6.50.

This is the seventh semirevised edition of a textbook first published in 1943. This edition is, like its predecessors, photo-offset from typewritten copy, but it has been completely reprinted in a type size similar to normal textbook size. New problems have been added, and answers are included for most problems presented. New material and figures have been added in various chapters, including new material on diagonal tension field beams. Professor Bruhn is head of the School of Aeronautics at Purdue University.

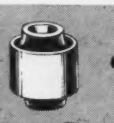


For CONSOLIDATED "240"
CURTISS CW-20 (C-46)
DOUGLAS DC-6 (C-112)
MARTIN 202

With Pratt & Whitney R-2800 A & B Series Engines use MR-36; Pratt & Whitney R-2800C Series Engines use MR-36F

Lord Dynafocals achieve minimum weight through careful design and accurate stress analysis. Their flexible center-of-gravity suspension gives maximum engine vibration isolation and smoother flight. Metal parts interlock for positive safety. All steel parts are 100% Magnafluxed for long life and satisfactory performance.

Write for a copy of Lord Service Bulletin containing valuable information on maintenance problems, suggestions for increased service life, and parts list. Mention engine or mounting in which you are interested.



COWL MOUNTS

INSTRUMENT PANELS, RADIO, NAVIGATION, COMMUNICATION EQUIPMENT

LORD MANUFACTURING CO
ERIE, PA.

Canadian Representative:
Railway & Power Engineering Corp. Ltd.

LORD
Vibration Control Systems

Evaluation of Residual Stress. K. Heindlhofer. New York, McGraw-Hill Book Company, Inc., 1948. 196 pp., illus., diagrs. $4.00.

The aim of this book is to present the methods and instruments necessary to carry out an experimental analysis of residual stress, defined as the stress that would exist in an elastic solid body if all the external forces, couples and applied stresses, acceleration, and gravitation were removed. The author, who is a physicist in the Research Laboratory of the United States Steel Corporation, was prompted to bring an up-to-date account of this subject together, because this had not been done since the invention of the electric strain gages and has never been done before in book form. In Chapter 1 the significance of residual stress in the metal industry is discussed. Chapter 2 deals with the limitation imposed on stress analysis by the nature of the metal, particularly the phenomena of deviation from proportionality, inhomogeneity, and anisotropy. In Chapters 3 and 4 are treated the pertinent phases of theory of elasticity (displacement, strain, and stress) and the critical representation of data. A discussion is included of the impossibility of calculating residual stress within the body from observations restricted to the surface. The detection and measurement of residual stress, and the necessary instruments, are discussed in Chapters 5 and 6. Examples of experimental stress analysis and interpretation of some of the results are discussed in the final chapter. Footnote references are given throughout.

The Measurement of Stress and Strain in Solids. Based on the Proceedings of a Conference Arranged by the Manchester and District Branch of the Institute of Physics on 11, 12, and 13 of July 1946. London, Institute of Physics, 1948. 114 pp. illus., diagrs.

Contents: Some Physical Characteristics of the Wire-Resistance Strain Gauge, Eric Jones; The Use of Resistance Strain Gauges in Combination with Particular Reference to the Measurement of Component Loads, F. Aughtie; High-Frequency Strain Gauges, E. P. George; A Note on the Use of Resistance Strain Gauges in Ships, F. B. Bull; A Review of Some Recent Developments in Photoelasticity, W. A. P. Fisher; The Photography of Photoelastic Stress Patterns, H. McG. Ross; A Note on Time-Edge Stresses in Photoelastic Models, J. W. Fitchie; A Review of Some Strain-Measuring Devices, C. E. Phillips; The Measurement of Strain in Metals by X-rays, D. E. Thomas; The Use of X-rays for Investigation of Residual Stresses in Ships' Structures, K. J. Pascoe; Note on Acoustic Strain Gauges, F. B. Bull; Summary of Additional Electrical Methods of Strain Measurement, G. E. Bennett.

THERMODYNAMICS

Engineering Thermodynamics, Theory and Applications. Jesse Seymour Doolittle and Alexander Hamilton Zerban. Scranton, Pa., International Textbook Company, 1948. 429 pp., illus., diagrs. $5.00.

This textbook was written to provide the basis for a 1-year course in thermodynamics for engineering students. The order of presentation is planned to present basic hypotheses, one at a time, from which further developments are made. Equations are held to a minimum in order to show how problems may be analyzed and solved by the application of a few fundamental principles. Equations of state for perfect gases, energy equations for nonflow processes, and steady flow take up the first fourth of the book. The Carnot cycle, vapors, steam power cycles, steam engines, flow in nozzles, steam turbines, and gas compressors are next discussed. In the second half of the book the discussion of more specialized concepts and applications continues, with chapters on refrigeration, gaseous mixtures and combustion, imperfect gases, air conditioning, gas cycles, internal combustion engines, and gas turbines. The authors are professors of mechanical engineering, respectively, at North Carolina State College and The Pennsylvania State College.

AIRSURANCE
Airline Passenger Insurance

Annual Policies
from $5,000 to $100,000
at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $38.00 per year

Policies cover all airlines in U. S. and American Flag lines world-wide — also airlines in Canada, Mexico and South America which meet safe operating standards.

Backed by the Combined Assets of
Aetna Casualty & Surety Co.
American Surety Co. of N. Y.
Century Indemnity Company
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Company
Travelers Indemnity Co.
United States Fidelity & Guaranty Co.

U.S. GROUP

WRITE OR PHONE ANY U. S. GROUP OFFICE

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 7, N. Y.
WASHINGTON ATLANTA CHICAGO LOS ANGELES

PIASECKI *wants*
Top Flight
ENGINEERS

• For Research, Development, Design and Production of Tandem Rotor Helicopters. Long term program offers exceptional opportunity for ambitious, progressive engineers with training and experience as—

• AIRCRAFT DESIGN ENGINEERS
• MECHANICAL DESIGN ENGINEERS
• STRESS ANALYSTS
• PROJECT ENGINEERS
• VIBRATION ENGINEERS
• FLIGHT TEST and INSTRUMENTATION ENGINEERS

WRITE

Giving Age, Experience and Education to—

PIASECKI HELICOPTER CORP.
Morton, Pa. (Phila. Suburb)

Members Elected

(*Continued from page 17*)

Kaplan, Joseph, Ph.D., Member, Special Subcommittee on Upper Atmosphere, N.A.C.A.; Member, Weather & Upper Atmosphere Panel, U.S.A.F. Scientific Advisory Board.

Lynch, Edward E., M.S., Head, Electrical Development Section, General Electric Co. (West Lynn Works).

Ours, Statton Ray, A.E., Comdr., U.S.N.; Chief Engineer, Naval Aircraft Factory (Philadelphia).

Stroukoff, Michael, C.E., President and Chief Engineer, Chase Aircraft Co., Inc.

Tsien, Hsue-shen, Ph.D. in Aero. & Math., Prof. of Aerodynamics, Dept. of Aero. Engineering, Massachusetts Institute of Technology.

Elected to MEMBER Grade

Becker, Herbert, B.C.E., Structures Engineer, Edo Corporation.

Benford, Robert Joseph, M.D., Col., U.S.A.F.; Chief, Engineering Development Div., Armed Services Medical Procurement Agency (Fort Totten).

Benson, Donald O., B. of Ae.E., Supt. of Aircraft Engineering, Northwest Airlines, Inc.

Bontya, John Michael, Sr. Stress Analyst, The Glenn L. Martin Co.

Bowles, Romald E., M.S., Mechanical Engineer P-2, Aerophysics Sub-Division, Naval Ordnance Lab. (White Oak).

Click, Gordon Eugene, B.S., Engineering Designer "B," Northrop Aircraft, Inc.

Close, Robert Andrew, Design Engineer, Ryan Aeronautical Co.

Corson, Blake Wilson, Jr., B.S., Aero. Research Scientist; Section Head, 16 Ft. High Speed Tunnel, N.A.C.A. (Langley Field).

Cullom, Kenneth S., B.S. in M.E., Technologist Engineer, Power Plant Engineering Div., C.A.A., Dept. of Commerce.

Cummaro, Louis Albert, Engineering Mgr., Rosan, Inc.

Deming, Arthur F., B.S. in E.E., Consulting Engineer in Dynamics, (Subsonic & Supersonic), Hughes Aircraft Co.

Duncan, William S., B.Sc., Design Engineer, Guided Missiles Div., Ryan Aeronautical Co.

Durant, Frederick C., III, B.S. in Ch.E., Lt. Comdr., U.S.N.R.; Executive and Engineering Officer, Naval Aero. Rocket Lab. (Lake Denmark).

Fiszdon, Wladyslaw, C.E. (Aero.), Associate Prof., Warsaw Institute of Technology.

Frowe, Eugene, M.A. in Physics, Chief of the Lab., Robert H. Ray Co.

Gelvin, Elvin R., Engineering Test Pilot, The Glenn L. Martin Co.

Gillmore, Alfred Edward, Chief Designer, Skyways, Ltd. (England).

Greinacher, Richard, Dipl. Ing., Chief Aerodynamicist, Service Technique Militaire (Berne); Supervisor of Aerodynamic Calculations, Federal Aircraft Factory (Emmen), Swiss Gov't.

Hutchison, Dale H., B.S., Executive Vice-President, Aviation Facilities Associates.

Klammer, Reuben G., B.S.Ae.E., Research Lab. Analyst "A," Northrop Aircraft, Inc.

Kroll, Wilhelmina D., B.S., Aero. Engineer P-3, National Bureau of Standards.

La Motte, Ralph R., M.S., Chief Engineer, Aeroproducts Div., General Motors Corp.

Lippert, Stanley, B.A., Research Analyst, Douglas Aircraft Co., Inc.

Miskam, Frederick C., B. of Ae.E., Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Paquette, Armand L., B.E., Mgr., Aviation Section, Westinghouse Electric Corp.

Rauth, J. Donald, B.S., Project Engineer, Guided Missiles Section, The Glenn L. Martin Co.

Robbins, Robert M., B.S., Asst. Project Engineer, Boeing Airplane Co. (Seattle).

Wilder, Stuart, Jr., M.B.A., Asst. Engine Engineer, Allison Div., General Motors Corp.

Transferred to MEMBER Grade

Clark, Gene Weldon, B.S., Maintenance Engineer, Braniff Airways.

Coar, Richard John, B.S. in M.E., Project Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Davis, Wallace F., M.S., Aero. Research Scientist, Section Head, 1 Ft. by 3 Ft. Supersonic Wind Tunnel Section, Ames Aero. Lab., N.A.C.A.

Drake, William Calvin, B.S. in Ae.E., Aero. Research Scientist, 1 Ft. by 3 Ft. Supersonic Tunnel Section, Ames Aero. Lab., N.A.C.A.

Geyer, Leo Alvin, M.S. in Ae.E., Asst. Chief of Aerodynamics, Grumman Aircraft Engineering Corp.

Gottlieb, Seymour, B. of Ae.E., Project Engineer, Structures Flight Test Section, Naval Air Experimental Station, U.S. Naval Base (Philadelphia).

Hunter, Maxwell W., M.S., Aerodynamics Engineer "A," Douglas Aircraft Co., Inc.

Jaeger, Bernard F., M.S. in Ae.E., Wind Tunnel Project Engineer, Naval Ordnance Test Station (Inyokern).

Kahlke, Charles Edwin, Jr., Private Engineering Practice, Consulting Organization.

Lee, William Marshall, B.S. in Ae.E., Aerodynamicist & Thermodynamicist, Northrop Aircraft, Inc.

Lin, Tung-hua, S.M. in Ae.E., Lt. Col., Head of Technical Mission, Chinese Air Force (England).

Linden, Jack Elmer, B.S.E. (Aero.), Head, Performance Analysis Section, Aerodynamics & Hydrodynamics Branch, Bureau of Aeronautics, Navy Dept.

Nelson, Thomas Arthur, B.S. in M.E., Flight Test Project Engineer, Boeing Airplane Co.

O'Brien, Edward Hawks, S.M. in M.E., Aerodynamicist "A," Douglas Aircraft Co., Inc. (Santa Monica).

Robinson, William Robert, B.S. in Ae.E., Layout Draftsman "A," McDonnell Aircraft Corp.

Sliney, Ralph Edward, Jr., B. of Ae.E., Aero. Engineer, Performance Unit, Flight Data Branch, Aircraft Projects Section, Engineering Div., Air Materiel Command, Wright-Patterson Air Force Base, U.S.A.F.

Stubau, Carl John, B.S. in M.E., Project Engineer, Pesco Products Div., Borg-Warner Corp.

Wilshusen, Russell Elmer, M.S. in Ae.E., Asst. Scientist, Rosemount Research Center, University of Minnesota.

Yorgiadis, Alexander John, M.S. in Engineering, Chief Engineer, Sonntag Scientific Corp.

Elected to Associate Member Grade

Butler, Richard Ogden, Time Study & Methods Engineer, Manhattan Rubber Div., Raybestos-Manhattan, Inc.

Charles, Eugene Burton, Service Representative, Ryan Aeronautical Co.

Hinmon, Donald LeRoy, B.S. in C.E. Mgr., Aviation Industry Section, Johns-Manville Sales Corp.

Sciarroni, Fulvio R., Experimental Supervisor, Helicopter Shop, McDonnell Aircraft Corp.

Elected to Technical Member Grade

Clevenson, Sherman A., B.S. in M.E., Aero. Research Scientist, N.A.C.A. (Langley Field).

Deneff, George V., M.S., Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Hartong, Thyra L., B.F.A., Engineer in Charge of Planning, Aircraft Div., Globe Corp.

Jeffords, Clifford C., A.S., Asst. Flight Test Analyst, Consolidated Vultee Aircraft Corp.

Panaccione, Peter Thomas, Designer & Checker, M. W. Kellogg Co.

Richardson, Albert Sherman, Jr., Jr. Development Engineer, Goodyear Aircraft Co.

Rom, Frank E., M.S. in Engineering, Aero. Research Scientist, Lewis Flight Propulsion Lab., N.A.C.A.

Rosenbaum, Harold M., M.A. in Math., Jr. Engineer—Mathematician, Cornell Aero. Lab.

Ross, Thomas Jay, Capt., U.S.M.C.; Officer in Charge, Flight Test & Inspection Depts., Overhaul & Repair, Marine Corps Air Station (Cherry Point).

Saff, Robert E., Engineer, Aircraft Div., Globe Corp.

Turner, Frederick Charles, Lt. (j.g.), Test Pilot & Naval Aviator, U.S.N.

Zabala, Federico C., M. of Ae.E., Capt., Engineer's Branch, Chilean Air Force.

Transferred to Technical Member Grade

Anderson, George A., Jr., Mathematician, Northrop Aircraft, Inc.

Ball, George A., M.S., Research Engineer, Harvard University.

Banovic, John A., S/Sgt., U.S.A.F.; Aircraft Sheet Metal Specialist & Aero. Draftsman, 66th Fighter Squadron.

Block, Donald Bruce, B.S. Ae.E., Jr. Weight Analyst, Goodyear Aircraft Corp.

Brewer, Roland Lee, Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Cortright, Edgar M., Jr., B.Ae.E., Aero. Research Scientist, Lewis Flight Propulsion Lab., N.A.C.A.

Cowell, Forrest E., B.S., Jr. Structural Test Engineer, The Glenn L. Martin Co.

Dalton, Malcolm George, Engineering Draftsman, Grumman Aircraft Engineering Corp.

Ergas, Isaac, B.M.E., Patent Examiner P-1, Patent Office, Dept. of Commerce.

Evans, Harry L., B.S.M.E. (Aero), Lt. Col., Group Commander & Sr. Pilot, U.S.A.F.

Falconer, Robert William, B.S., Asst. Research Engineer, Propulsion Div., McDonnell Aircraft Corp.

Findley, Lester Jack, Tool Designer "B," Douglas Aircraft Co., Inc. (Long Beach).

Fisher, Richard R., Jr. Designer Engineer, Goodyear Aircraft Corp.

Fox, Harold L., B.S., Sr. Draftsman, Goodyear Aircraft Corp.

Gilbertson, Arnold O., B. of Ae.E., Mathematician, Douglas Aircraft Co., Inc. (Santa Monica).

Gratzer, Louis Bernard, B.S. in Ae.E., Part-time Instructor & Research Associate in Aero. Engineering, University of Washington.

Gunsolus, Ann Elizabeth, B.Ae.E., Research Fellow, Aero. Dept., Polytechnic Institute of Brooklyn.

Hall, James R., B.Ae.E., Aero. Engineer, Pilotless Aircraft Research Div., N.A.C.A. (Langley Field).

Hawk, Carl David, B.S., Jr. Engineer, Gas Turbine Fuel Controls, Bendix Aviation Corp.

Jackson, H. Herbert, B.S. in M.E. (Aero.), Aero. Engineer, N.A.C.A. (Langley Field).

Jacob, Howard E., B.S.Ae.E., Engineering Asst., General Electric Co.

Janssen, Edzard William, B.S.Ae.E., Weight Analyst, Goodyear Aircraft Corp.

Kelly, Robert B., B.S. in Ae.E., Draftsman "A," Wing Group, Douglas Aircraft Co., Inc. (El Segundo).

Kraptovich, Edward Stephen, B.S.Ae.E.

Kyhl, Edith K., M.S.

Leonard, Lewis A., Jr., A.E., Asst. Project Engineer, Aeroproducts Div., General Motors Corp.

McKee, Frank W., Jr., Data Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Milling, Robert W., B.Ae.E., Aero. Engineer P-1, N.A.C.A. (Langley Field).

Peters, Glenn M., Draftsman, Design Group, Northrop Aircraft, Inc.

Prouty, Emery M., Engineering Draftsman, Testing Equipment, Northrop Aircraft, Inc.

Resnick, Herbert Robert, B.S., Supervisor and Field Engineer, Zaro Co.

Riccius, Merril V., B. of Ae.E., Jr. Engineer, Design Operations Section, Chance Vought Aircraft Div., United Aircraft Corp.

Sledge, Marvin, B.S., Col., U.S.A.F.; Air Force Plant Representative, Allison Div., General Motors Corp.

Stathis, Peter, B.S.Ae.E.

Taylor, Roger C., Engineering Draftsman, The Glenn L. Martin Co.

I.A.S. National Meeting Schedule

Sixth Personal Aircraft Meeting—Hotel Allis, Wichita, Kan.—April 29–30

Second Joint I.A.S.-R.Ae.S. Conference—New York—May 24–26

Annual Summer Meeting—Los Angeles—July 21–22

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to
The Meetings Committee
Institute of the Aeronautical Sciences
2 East 64th Street, New York 21, N.Y.

Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute

WANTED

Top Flight Rocket Engineer—Familiar with acid-gasoline motors, to act as project engineer and coordinate the activities of staff engineers responsible for the design of various individual rocket motor components and the coordination and assembly of these components into a completed rocket motor. Address replies to: Mr. David Gregg, Administrative Engineer, Rocket Department, Curtiss-Wright Corporation, Propeller Division, Caldwell, N.J.

Electrical (Electronics) Engineers—Project Engineers, Designers, recent graduates. **Mechanical and Electrochemical Designers**—Minimum, 3 years' experience. **Layout Draftsmen (Electrical)**—Minimum, 3 years' experience design and layout electronic chassis. **Layout Draftsmen (Mechanical)**—Minimum, 3 years' experience design and layout small mechanisms, automatic machinery, etc. **Aerodynamicist (Aeronautical Engineer)**—Recent graduate or experienced. Mechanical engineering ability helpful. **Electrical (Electronics) Production and Manufacturing Engineers**—For supervisory manufacturing and production positions. Actual electronic production supervision experience essential. **Field Service Men, Electronic-Electromechanical**—Aviation background desirable. Recent graduates or experienced men. Will be trained at plant for field work. Single men preferred. Liberal expense and travel allowances. **Writers, Artists, Parts Catalog Compilers**—Technical publications. Experience essential, preferably on Government manuals covering electronic devices. **Inspectors, Electrical and Electronic**—Qualified in establishing electronic inspection procedures. Experience essential. These men needed immediately for interesting and permanent positions on an experimental, development, and production program of complex electronic and electromechanical equipment. Work covers computers, servos, amplifiers, instrumentation, small mechanisms in aircraft simulation for complex training equipment. Applicants should have college degree, equivalent experience, or both. Interviews will be arranged. Write Personnel Manager, Link Aviation, Binghamton, N.Y.; specify particular opening, qualifications, and salary expected.

Instrumentation Engineers—The Flight Test Division of the Naval Air Test Center, Patuxent River, Md., has the following vacancies: Electrical Engineer, P-4, $5,232; Mechanical Engineer P-4, $5,232; Mechanical Engineer P-3, $4,479.60; Electrical Engineer P-2, $3,727.20; Engineering Aide, Electrical SP-8, $3,727.20; Engineering Aide, Mechanical SP-8 $3,727.20. Assignments include strain-gage instrumentation, special flight installations, instrument developments, evaluations, and studies. Fill out Civil Service Application form 57, obtainable at local post offices, and forward to: Industrial Relations Division, Naval Air Station, Patuxent River, Md.

Aeronautical Engineer—The Naval Air Test Center has an opening for an aeronautical engineer, power-plant specialist, to present courses of instruction on a college level in power-plant operation and installation and to do development work in the field of flight testing. Any applicant for this position should have at least a Bachelor's Degree in aeronautical engineering plus several years of teaching and/or industrial experience. Depending on the qualifications of the applicant, the position is either a civil service P-4 or P-5 paying from $5,232 to $6,235 per annum. Adequate low-cost Government housing for the man selected and his family is available immediately. All letters should be accompanied by completed copy of civil-service application form 57 obtainable from your local post office. Letters of application for this position should be addressed to: Director, Test Pilot Training Division, Naval Air Test Center, Patuxent River, Md.

Rocket Designer—Position available for graduate engineer experienced in development of rocket motor and missile launching equipment. Salary open. Personnel Office, Hughes Aircraft Company, Florence Ave. at Teale St., Culver City, Calif.

Industrial Engineer—U.S. Civil Service Grade P-5, starting salary $6,235.20 per year. *Basic Requirements:* A graduate engineer, experienced in methods, cost control, and budgeting work. Will be expected to initiate studies and work with cognizant department heads toward more efficient use of research and development and support funds through improvement of organization and improved use of man power. Will initiate and supervise maintenance of work measurement and progress record programs. Applications for the above position should be filed with the Executive Secretary, Navy Department, Joint Board of U.S. Civil Service Examiners, 1030 E. Green St., Pasadena 1, Calif.

Thermodynamicist; Flutter Engineer—M.S. in engineering, with some training in aeronautics. Thorough mathematical background, working knowledge of compressible fluids, engineering thermodynamics and heat transfer, experience in gas-turbine work preferred. For analysis and development work on engines for advanced military aircraft. Also Flutter Engineer: A.E. graduate with several years' experience in flutter and vibration problems. Salaries commensurate with training and experience. Please include complete summary in reply to Engineering Personnel Office, North American Aviation, Inc., Los Angeles Airport, Los Angeles 45,Calif.

Aeronautical Engineers—Fairchild Aircraft Division, Hagerstown, Md., has vacancies in its Engineering Department at Hagerstown and also branch engineering office, Washington, D.C., for engineering draftsman, layout engineers, aerodynamicists, electrical engineers, structures, and research engineers (with Ph.D. in Math or Physics). For immediate details write Employment Manager, Fairchild Aircraft Division, Hagerstown, Md.

Engineers—Engineering draftsmen, engineering designers, and aerodynamicists for research and development work on B-36, world's largest bomber, and other advanced Air Force designs. Positions are also available for tooling personnel. Write for application blank to Engineering Personnel Office, Consolidated Vultee Aircraft Corporation, Fort Worth, Tex.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

AVAILABLE

954. Project Engineer—M.I.T. Aeronautical Graduate. Eight and one-half years' experience with well-known aircraft company and research laboratory. Past 3 years as research project engineer on guided-missile program. Well-rounded background as supervisor in physics, flight test, aerodynamics, and wind tunnel sections. Capable of responsibility for technical, administrative, and customer-contact phases on aeronautical projects. Desires position with progressive organization conducting research and development on aeronautical tasks. Age 30; married; available immediately.

953. Aeronautical Engineer—B. Aero. E., 1940. Wishes supervisory position in Engineering Department in foreign country. Is facile in learning languages. Nine years' experience with three major aircraft companies as Junior Inspector, Draftsman, Senior Draftsman, Designer, Group Leader, Checker, Assistant Chief Checker. Experienced in analysis of drawings and designs in sheet metal or solid stock for clearness of presentation, practicality of design, ease of manufacture. Has done original writing and compilation for Design Section of Drafting Room Manual. Presently on loan to Engineering Test Laboratory because of electronic background.

952. Aeronautical Engineer—Thermodynamicist, aerodynamicist. B.A.E.; at present studying for Master's degree in M.E. Age 32; married. Eight years' mechanical background—shop, inspection, instruments, laboratory, and test work. Two years' supervision. Two years' mechanical design, drafting. Two and one-half years' research-guided missiles, control and stability, cabin air cooling systems for supersonic aircraft. Reciprocating engine cooling studies. Report writing of proposal studies. Open to other fields of engineering and engineering for production. Will consider leaving New York.

951. Aeronautical Engineer—M.S.; age 44. Twenty-three years' experience in aviation. Thirteen years' experience as Chief Design Engineer; was responsible for 25 different types of trainer, touring, transport, and military planes. Experienced in stress analysis and aerodynamics, including performance stability and performance tests. Familiar with British Airworthiness Requirements and Civil Aeronautics Administration Regulations. Eight years' experience as organizer, supervisor, consultant, and chief engineer of a newly built airplane factory. Thirteen years' experience as performance test pilot. Twenty years' teaching on Applied Aerodynamics and Airplane Design, including some wind-tunnel operations. Desires position as engineer in airplane design or research.

950. Administrative Assistant or Industrial Engineer—B.S. Aero. E., B.S.M.E. 1945; M.S. in Management in February, 1950. Age 23. One year's experience as Administrative Assistant in charge of Engineering Planning and Control, including job breakdowns, status reports, etc. Two years as Mechanical Engineer, including design work, test programs, progress report writing, shop liaison, etc.

949. Aeronautical & Mechanical Engineer—B. Aero. E. Registered M.E. (California); 2 years Liberal Arts, U.C.L.A. extension courses in Business Administration. Total of 6 years' ex-

MINIATURE SPEED CHANGERS
★
COMPLETE
COMPACT
ADAPTABLE

- Over 500 different Standard ratios! 10:9 to 3375:1
- SMALL! 1.050" Diameter. Overall lengths: Type 5A, 3-3/16" Type 5B, 4-1/32" Type 5C, 4-13/16"
- Transmit power either way up to 230:1 ratios!
- Concentric ball-bearing input and output shafts.
- Hardened steel spur gears.
- Permanent lubrication.
- Prompt deliveries on production or experimental quantities.

BULLETIN No. 100
Gives complete details—Write for it today to METRON INSTRUMENT COMPANY, 426 Lincoln Street, Denver 9, Colorado

BUILT BY Metron MAKERS OF INSTRUMENTS FOR PRECISION MEASUREMENT

DEPENDABILITY ✓
YOU'VE GOT IT — WITH A "CAL-AERO TECH" GRADUATE
— DESIGNERS AVAILABLE —
Immediately useful, without break-in
EXPERIENCE
4000 hours on board and in aircraft shops, with fundamentals and actual work assignments under supervision of Aircraft Factory Experienced Designers—Specializing in design of component parts—proficient in layout, strength checking and manufacturing process analysis.
HIRE A "CAL-AERO" GRADUATE—HE'LL DELIVER THE GOODS
NEW CLASS GRADUATES EACH MONTH
Serving DOUGLAS • LOCKHEED • NORTH AMERICAN • BOEING NORTHROP • CURTISS-WRIGHT • CONVAIR • RYAN AIRESEARCH and MANY OTHERS
PHONE OR WRITE
CAL-AERO TECHNICAL INSTITUTE
GRAND CENTRAL AIR TERMINAL • GLENDALE 1, CALIF.

ENGINEERS—

Expanding Engineering Department of North American Aviation, Inc., needs qualified

AERODYNAMICISTS
THERMODYNAMICISTS
STRESS ANALYSTS
AIRCRAFT DESIGNERS
FLUTTER ENGINEERS

and specialists in all phases of aircraft engineering, for work on military projects. Please include summary of experience in reply.

Engineering Personnel Office
NORTH AMERICAN AVIATION, INC.
Los Angeles Airport, Los Angeles 45, Calif.

DESIGN ENGINEERS
LAYOUT AND DETAIL DRAFTSMEN
TECHNICIANS

Unique opportunities await you in the new and challenging field of utilization of nuclear energy for the propulsion of aircraft.

Design engineers with five years' experience in the field of original design and development of conventional and jet type aircraft power plants, control mechanisms, servo systems, installations and test equipment.

Draftsmen with three years' experience on aircraft power plant components. Experience in fields other than aircraft may be applicable to those interested in a radically new design field.

Positions also available for technicians, experienced in set up and operation of test rigs.

In reply, please forward resume of education, experience, salaries and pertinent personal data to:

Employment Office
FAIRCHILD ENGINE AND AIRPLANE CORPORATION
NEPA DIVISION
P. O. Box 415, Oak Ridge, Tennessee

PROJECT ENGINEERS

Real opportunities exist for Graduate Engineers with design and development experience in any of the following: Airplane Stability and control, Servomechanisms, radar, microwave techniques, microwave antenna design, communications equipment, electron optics, pulse transformers, fractional h.p. motors.

SEND COMPLETE RESUME TO EMPLOYMENT OFFICE
SPERRY GYROSCOPE CO.
DIVISION OF THE SPERRY CORP.
GREAT NECK, LONG ISLAND

Aircraft Engineering
FOUNDED 1929
The Technical and Scientific Aeronautical Monthly
Edited by Lt.-Col. W. Lockwood Marsh
F.I.Ae.S., M.S.A.E., F.R.Ae.S.

Single Copies: 50 cents post free
Subscription: $6.50 per annum, post free

BUNHILL PUBLICATIONS LIMITED
12 Bloomsbury Square London : : W.C.1 England

perience in research and development of structural and functional aircraft components, rocket launcher design and testing, aircraft maintenance. Technical Director of export-import firm (1 year). Age 31. Prefers position on West Coast in Research, Administrative, Service or Sales Engineering.

948. Engineer-Lawyer—with wide knowledge of technical phases of aviation, consider association with manufacturer as assistant to top executive. Will offer effective public relations representation, planning and promotional ability, and unusual thoroughness in assignments of detail analysis.

947. Public Relations—Technical Journalist—With broad experience on foremost publications, is interested in becoming associated with progressive organization desiring representation in field of aviation.

946. Aeronautical Engineer—B.Sc. in Ae.E.—M.I.T., 1947. Age 26; married. Since graduation has had 8 months' teaching experience at an Eastern university and 10 months' experience in air transport organization. Holder of C.A.A. A and E license. Approximately 4 years' technical experience previous to attendance at M.I.T. as airplane technician. Prefers employment with an air transport organization.

945. Aeronautical Engineer—B.S. from Carnegie Tech. Twelve years of aerodynamic, structural, power-plant and flight-test experience with major aircraft manufacturers. Steady advancement to supervisory positions. Now in business for self but wishes to return to aircraft work. Age 33; married; pleasing personality and energetic worker.

944. Aeronautical Engineer—B.A.E., Age 27; married. Five years' experience; $1\frac{1}{2}$ years in research on missile guidance components; 1 year in aircraft flight test; 1 year in wind-tunnel group; $1\frac{1}{2}$ years as Navy aircraft engineering officer. Desires position with a challenge.

943. Aeronautical Engineer—B.A.E., 1943. Age 25; married. Four years' experience in high-speed stability and control wind-tunnel research work, including organizing and directing projects, designing specialized equipment, analyzing data, and writing technical reports. Graduate studies include stability and control and supersonic aerodynamics. Familiar with latest Army and Navy specifications on stability and control; experience in liaison between design and testing groups. Desires supervisory position involving stability and control design or semiliaison position involving supervision of specialized equipment design in related field.

942. Gas Dynamicist—B.S. and M.S. in M.E. from M.I.T. Age 30. Advanced fluid mechanics, heat transfer, and thermodynamics. Experience in analysis, research and development of jet propulsion power plant. Desires permanent and responsible position, possibly with opportunity to continue work toward D.Sc. Available by Summer, 1949.

941. Aerodynamic and Flight Test Engineer—B.Ae.E. from New York University. Now taking Masters Degree in M.E. at University of Pennsylvania. Some experience at flight-test data evaluation, flight-test instrumention, and aerodynamic performance analysis. Desires position as Junior Engineer at location that will permit continuation of graduate studies. Single; age 20.

940. Aeronautical Engineer—B. Aero. E., 1938. Ten years' experience in aircraft production, material, new design, and sales-engineering. Past 3 years domestic and foreign sales contact work; has supervisory and public relations experience.

939. Aeronautical Instructor—Administrator—Unusual background: Degree in physics, also major in chemistry, Johns Hopkins. Three years teaching and administrative experience, U.S.A.F. technical schools in engine test, carburetion specialization, flight-line maintenance. Instructor in aviation mechanics for the Brazilian Air Force and assistant chief of the Engineering Projects Division for the Brazilian Ministry of Aeronautics, serving as administrative chief of 400 Brazilian technicians. Considerable experience in personnel administration in the U.S.A.F. as civilian chief instructor and also as engineer in Brazil. Has just returned from a 3-year stay in South America. This last year spent only in traveling and observing all South American countries. Can speak and write fluent Portuguese and Spanish. Any location.

938. Personnel Manager—B.S. Ae.E. and M.S. in Industrial Psychology, both Purdue. Two years engineering department international air line. Present position—personnel manager, West Coast firm. Location open.

937. Aeronautical Engineer—Swedish aircraft engineer who visited U.S.A. during 8 months in 1947 wants to come back. Head of Air Force project group, experienced in transonic and research aerodynamics, stress analysis, and project engineering. Eight years' experience in teaching. Advanced degree in aeronautical engineering 1945 at the Royal Institute of Technology in Stockholm (Civilingenjor). Age 31; married.

936. Management or Executive Engineer—Graduate Engineer, age 37, with over 13 years of aircraft experience on Navy airplanes with one company. Background involves: approximately 7 years' experience in stress, analysis, airplane structural design and testing including responsible charge of the stress analysis section; over 5 years in project engineering work in charge of the design and development of an experimental and major production Navy airplane, including broad engineering administrative and supervisory experience in responsible charge of all design development work and customer contact on several airplane designs; over a year's experience in a manufacturing supervisory capacity. Desires a responsible position with an aircraft manufacturer or allied industry seeking management or executive talent.

Compactness, Low Weight for America's *Finest* Products

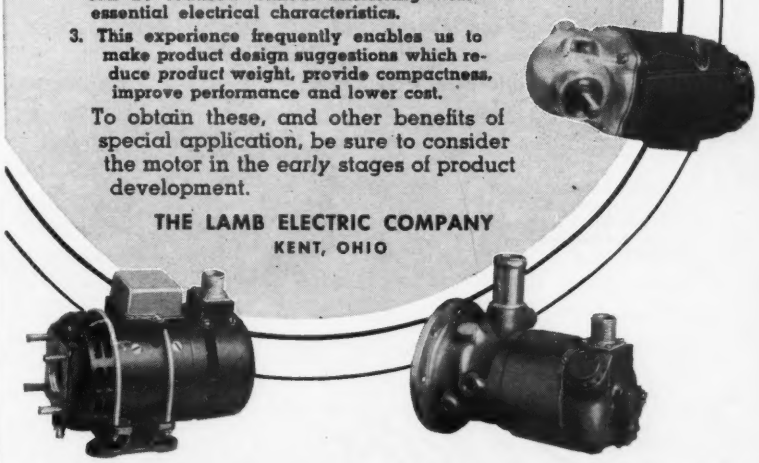
Lamb Electric MOTORS

Your new or redesigned product can be given these important advantages by using a Lamb Electric Motor because:

1. **Every motor is engineered for a particular application.**
2. **34 years' experience in motor engineering has taught us where and how much weight can be reduced without interfering with essential electrical characteristics.**
3. **This experience frequently enables us to make product design suggestions which reduce product weight, provide compactness, improve performance and lower cost.**

To obtain these, and other benefits of special application, be sure to consider the motor in the *early* stages of product development.

THE LAMB ELECTRIC COMPANY
KENT, OHIO



Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

F-80 Lockheed Shooting Star

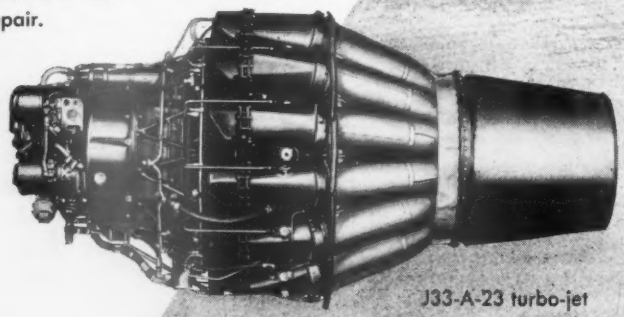
PROVED PERFORMANCE

With a total of more than 100,000 hours of actual flight time in their log book, Allison aircraft turbine engines have proved themselves with dependable performance under many varying conditions of service and of weather. Now operating 300 hours before overhaul, Allison J33 jet engines offer more useful service in the air with less lost time on the ground for service and repair.

Air Power is Peace Power

★ ★ ★

Other Allison-powered airplanes:
Republic F-84 Thunderjet
North American FJ-1 Fury
Northrop YB-49 Flying Wing
Grumman F9F-3 Panther



J33-A-23 turbo-jet

Allison

Builder of axial and centrifugal flow turbine engines

DIVISION OF GM GENERAL MOTORS

Indianapolis, Indiana

Index to Advertisers

A

Aeronautical Engineering Index 69
★Airborne Accessories Corporation 16
AiResearch Manufacturing Company Division, The Garrett Corporation 61
Allison Division, General Motors Corporation 106
★American Phenolic Corporation 91
Arkwright Finishing Company 50

B

B. H. Aircraft Company, Inc. 97
Bendix Aviation Corporation
Bendix Products Division 71
★Eclipse-Pioneer Division 55
★BG Corporation, The 51
★Borg-Warner Corporation, Pesco Products Division 67
Brush Development Company, The 108
Bunhill Publications Limited 104

C

Cal-Aero Technical Institute 104
★Clifford Manufacturing Company Division, Standard-Thomson Corporation 63
★Curtiss-Wright Corporation, Propeller Division 95

D

Douglas Aircraft Company, Inc. 88
Dow Corning Corporation 14

E

★Eaton Manufacturing Company, Saginaw Division 48
★Eclipse-Pioneer Division, Bendix Aviation Corporation 55
Elastic Stop Nut Corporation of America ..... Back Cover
Electrol Incorporated 73

F

Fairchild Engine and Airplane Corporation, NEPA Division 104
★Foote Bros. Gear and Machine Corporation 57

G

G&O Manufacturing Company, The 98
Garrett Corporation The, AiResearch Manufacturing Company Division 61
★General Electric Company, Apparatus Department ..... Inside Front Cover
General Motors Corporation, Allison Division 106
★G. M. Giannini & Company, Inc. 98
B. F. Goodrich Company, The, Aeronautical Division .. 53
Goodyear Tire & Rubber Company, Aviation Products Division 1

H

Hagan Corporation 81
Handy & Harman 96
Hoover Electric Company 62

I

Imperial Pencil Tracing Cloth, Keuffel & Esser Company . 98
International Nickel Company, Inc., The 4

K

Keuffel & Esser Company 64, 65, 98
Walter Kidde & Company, Inc. 83
★Kollsman Instrument Division, Square D Company 90

L

Lamb Electric Company, The 105
Linear, Inc. 59
Lockheed Aircraft Corporation 92, 93
★Lord Manufacturing Company 100

M

Metron Instrument Company 104

N

North American Aviation, Inc. 104

O

Ohio Seamless Tube Company, The ..... Inside Front Cover

P

★Pesco Products Division, Borg-Warner Corporation 67
Photoswitch, Inc. 76
Piasecki Helicopter Corporation 100

R

Republic Steel Corporation 85

S

★Sperry Gyroscope Company, Division of The Sperry Corporation 104
★Square D Company, Kollsman Instrument Division 90
★Standard-Thomson Corporation, Clifford Manufacturing Company Division 63
Surface Combustion Corporation, Aircraft-Automotive Division 79

U

United States Aviation Underwriters Incorporated 100

W

Wyman-Gordon Company 2

★ *Specifications and further information on the aircraft products of these companies will be found in the*

1949 AERONAUTICAL ENGINEERING CATALOG

The only publication of its kind devoted exclusively to the aircraft industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft materials, parts, and accessories. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading Aircraft, Aircraft Engine, Instrument, Accessory, and Aircraft Parts Manufacturers; Air Transport Companies; Army, Navy, and Governmental Agencies; Research Organizations; Engineering Libraries; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

Here's how...

to measure and record displacements from 10 to 10,000 microinches!

"Contour Analyzer" consisting of pickup head, BL-309 Amplifier and Brush Direct-Inking Oscillograph.

The "Contour Analyzer" is an instrument designed to record small displacements from a given reference point or line. Its sensitivity is such that movements as small as 10 microinches can be readily recorded and measured on the chart of the Brush Direct Inking Oscillograph. It can be used in a great number of applications involving small displacements, static or dynamic. Typical uses are as a recording micrometer, vibration recorder, pressure and force recorder, etc. In particular, the instrument lends itself well to the measurement of errors in the contour of irregularly shaped sections.

Specifications

Displacements measurable, 10 to 10,000 microinches	
Frequency Response (overall)	Essentially uniform d-c to 100 cps
Feeler Arm Travel	.015" approximately
Feeler Arm Force	Adjustable
Minimum	approximately 1½ oz.
Amplifier Dimensions	Length, 17¼"... Width, 11"... Height, 7½"
Amplifier Power Requirements	100 watts

Write or call

THE Brush DEVELOPMENT CO.

[illegible] Cleveland 14, Ohio, U.S.A.

[illegible] RECORDING DIV. — ACOUSTIC PRODUCTS DIV.

[illegible] CRYSTAL DIVISION

Canadian Representatives: A. C. Wickman (Canada) Ltd., P. O. Box 9, Station N, Toronto 14